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THE
ECONOMIC PROCEEDINGS
OF THE
Royal Dublin Society.

Vol. I. NOVEMBER, 1899. Part I.

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ERRATUM.

Page 154, line 16 from top, for *abetis*, read *abietis*, and similarly in Explanation of Plate I.

THE

ECONOMIC PROCEEDINGS

OF THE

Royal Dublin Society.

I.

THE IRISH PEAT QUESTION.

By T. JOHNSON, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, and Keeper of the Botanical Collections, Science and Art Museum, Dublin.[1]

[Received for Publication, February 1, 1899; Published November 21, 1899.]

Part I.—PEAT AND ITS DERIVATIVES.

I wish to bring before the Society some of the results of a visit I paid this summer (1898) to Germany, in connection with the development of the economic botanical collections in my charge in the Science and Art Museum, and also to call attention to a large collection of peat derivatives presented to the Museum, in part by Prof. Conwentz, of Danzig, from whom some Swedish as well as German specimens have been received, and in part by H. Schreiber, of Staab, in Bohemia, by whom a very large collection of specimens of peat derivatives has been presented to the Museum. I was particularly fortunate in my visit to Bavaria, receiving every kindness at the hands of Profs. Baumann and Tubeuf at the Bernau Experimental Bog Station. I hope in a second paper to give an account of the investigations going on there, having as their object the improvement of bog-land.

---

[1] Part I. of this Paper was read before the Society, December 21, 1898; Parts II. and III., February 22, 1899.

We have in Ireland 1861 square miles of bog land, of which the greater part is in the three counties of Donegal, Mayo, and Galway, three of the poorest counties in the country. Anyone who has been through these districts must have seen their backward condition. Failing this, one can read the reports on different districts Dr. C. B. Browne is communicating from time to time to the Royal Irish Academy from an anthropological point of view.

While the average thickness of turf in Europe is 9–20 feet, Ireland has beds as much as 40 feet thick, the average being 25 feet. At present, Irish turf is, with a few exceptions, simply used as fuel for burning, and even this is not prepared under the best conditions. On the continent, beginning, it seems, with the year 1883, there have been great improvements in the machinery used in the turf industry, as well as many remunerative industries in the applications of turf, started.

The object of this Paper is to bring some of these recent improvements and developments before the Society in the hope that bog owners will be able to take general advantage of them.

It is unfortunate that the terms "peat," "turf," "peat-fibre," "peat-litter," are made to do duty for a number of quite different substances, with a certain amount of resulting confusion.

The surface of a bog consists of pure Sphagnum or peat-moss, of other mosses, *e. g.* Hypnum, of flowering plants such as heather (Erica), Vaccinium, cotton-sedge (Eriophorum), beaked sedge (Rhynchospora), sedges, rushes, certain grasses, pines, &c., the nature of the flora being dependent on the kind of bog, whether high peat bogs (Hochmoore), fens (Grünlandsmoore), or morasses, (Wiesenmoore). Sphagnum and heather are characteristics of the high peat-bogs, and are absent from the morasses where the moss Hypnum, rushes, and sedges are the chief representatives of the flora. The surface of a bog may thus be pure peat-moss (Sphagnum), or a varied mixture of plants into which Sphagnum itself may not even enter.

TRUE MOSS-LITTER.

Sphagnum is the source of the true or best moss-litter, and a general account of it from an economic aspect will be of service here. Sphagnum is a moss having a number of characters which mark it off from other mosses, and cause it to stand in an order by itself.

Like other mosses, Sphagnum (fig. 1) grows in tufts, often of large extent, its social or cæspitose habit being due to the formation of new plants by a process of innovation. The stem of the parent plant is continually increasing in length and growing upwards. At the same time branches arise, the part of the stem below, common to both parent stem and branch, decays; the two become separate, and so two independent plants are formed. By constant repetition of this process tufts are formed, and the Sphagnum spreads. There are no true veins or vascular bundles in Sphagnum; it being a non-vascular cryptogam. The stem shows a central pith of thin-walled cells. Surrounding this is a cylinder of thick-walled more or less spindle-shaped cells which give a certain amount of firmness to the stem, having more or less lignified walls. This tissue is the only part of the Sphagnum which can be called

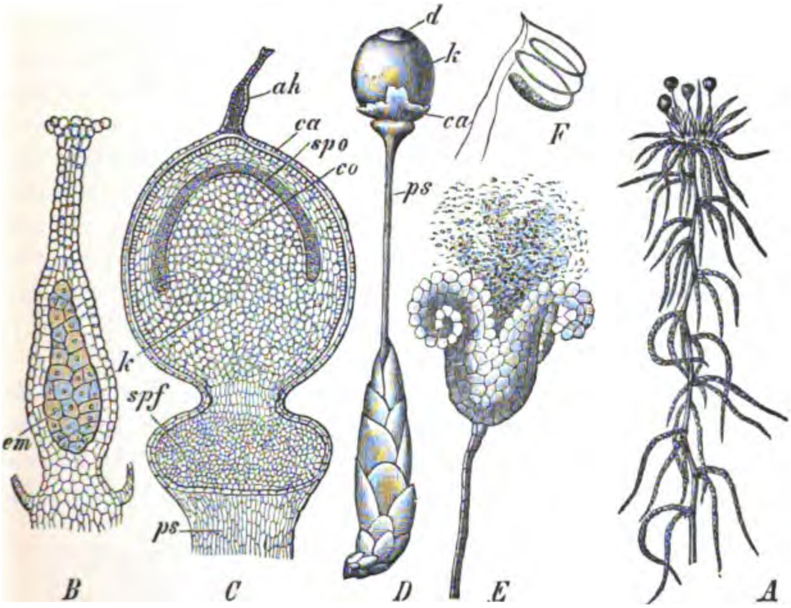

FIG. 1.[1]—*A.* Sphagnum in fruit: *D. k,* Fruit; *ps.* Stalk magnified.

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[1] Figs. 1 and 2 are reproduced, by permission, from the "Textbook of Botany" by Strasburger, Noll, &c. (Macmillan & Co.)

fibrous. The stem is, even with its support, too weak to stand upright alone. The members of a tuft mutually support one another in maintaining an upright position in the bog. Outside this comes a sort of cortex which varies in character in different species of Sphagnum (fig. 2).

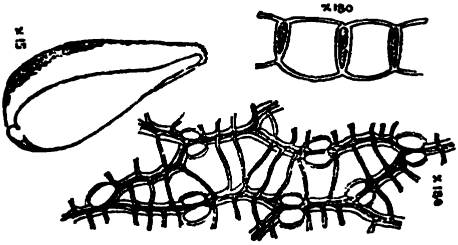

FIG. 2.

In *S. cymbifolia* it is well-developed; in *S. cuspidatum* (fig. 3) it is very poorly developed. In *S. cymbifolia* the cortex consists of four or five layers of dead cells, with holes in their walls, &c. putting the cells into open communication with one another and the water, &c., in the bog. These cells, though dead, are not functionless, but serve to draw up as a capillary system the water from the lower part of the plant or from the bog. Similar cells with similar functions are found in the leaves (fig. 4, *A. w.*). Each ordinary leaf of Sphagnum is one layer of cells thick; the living cells of the leaf form a network of long narrow cells containing protoplasm and chlorophyll grains or leaf-green grains, and making starch as in the higher plants. The meshes of this living network are filled by relatively large hyaline cells of the kind just described. A plant of Sphagnum in which these cells are well developed in stem and leaf possesses a very efficient absorptive, sponge-like tissue, and its presence accounts for the fact that a dried tuft of Sphagnum or peat-moss will absorb as much as nine times its weight of water.

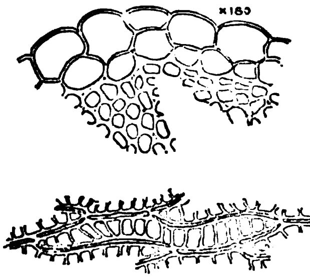

FIG. 3.

This absorptive tissue is best developed in species of the Cymbifolia group of which one species, *S. cymbifolia* (fig. 2) is frequent, while its sub-species, *S. papillosum*, is described as not uncommon in the North-East of Ireland. The species *S. Austini* is also a member of this group, but of rare occurrence in Ireland. Some time ago Canon Russell called on me, with some turf-balls, and asked me to make a microscopic preparation of one with a view to identification. The material was, though countless ages old, when turned up by the plough, so well preserved as to be readily identifiable as the moss *S. Austini.* Canon Russell has since found it in the living state in King's County, in great quantity. I have no doubt there is there a very profitable bog of particularly good peat-litter.

On the other hand in the *S. cuspidatum* group the stem absorptive tissue is not so well-developed, the leaves being the chief agent of absorption. *S. cuspidatum* is common. Other things being equal, it is evident that the *cymbifolia* group makes the best moss-litter, and the *cuspidatum* group the worst. The degree of decomposition as one digs into the bog is a very important factor. The more decomposed the peat is, the poorer it is as a moss-litter. Bogs vary very much in this respect. One bog may have good recognisable Sphagnum to a depth of 12 feet, another to a depth of only 3 feet. It is important to remember that the poorest Sphagnum litter is more absorptive than any other substance.

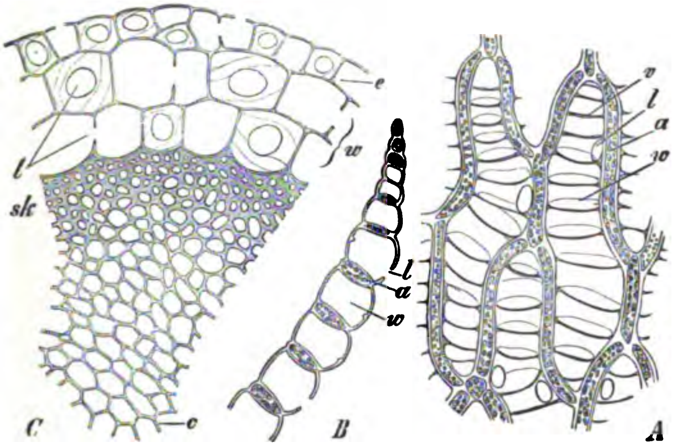

FIG. 4.—*A.* Leaf, in part, surface view; *B.* Leaf in section; *w*, the empty cells, with *l*, holes in their walls; *C.* Stem in cross section; *w*, *e*, the spongy cortex.

Thus Sphagnum absorbs 7–9 times its own weight of liquid;

Hypnum (the moss of morasses),	3 times.
Straw,	3 times.
Wood-wool or sawdust,	3–4 times.

The absorptive capacity of the Sphagnum is largely affected by the characters of the infiltrating matter of the bog. If there is much clay of a slimy character, this will get into the cells and coat them externally, and seriously lessen the value of the peat-moss as litter.

Mode of action of the Sphagnum.—The perforated cells of the stems and leaves of the dried peat-moss are filled with air. When the moss is trodden down, the air is squeezed out of the cells. The pressure being removed, the elasticity of the cell-walls comes into play, the cells enlarge, and any stable liquid or gas there is in the immediate neighbourhood is absorbed.

I am told that the Bog of Allen, generally, with an extent of 370 square miles, is singularly deficient in good surface Sphagnum, and is not on that account the very best source of peat-litter. A useful piece of economic work would be a thorough survey of the Irish bogs from the peat-litter point of view.

The advantages claimed for peat-litter as bedding for horses, cattle, pigs, &c., are now well-known, but it may be useful to reproduce them here. They are contained in a Parliamentary Paper (C. 6913, price 2½*d.*), entitled Reports from Her Majesty's Representatives on the Manufacture of Fuel, Moss-Litter, and other Products of Peat in European Countries. They are :—

1. Peat-litter affords drier and healthier bedding for horses and cattle than any other material.

2. In consequence of its great power of absorbing moisture, it binds the valuable portion of the animal excrements, and, consequently, yields the best manure.

3. It acts as a disinfectant, and improves the air of the stable.

4. A smaller quantity of it is required than would be needed if straw were used.

To these may be added that:—

5. Straw now used would be saved for fodder. (Peat-litter costs 18*s*. a ton; straw, a good food, 22*s*. to 35*s*. a ton).
6. Forest litter would be similarly saved. (This advantage is not at present applicable to Ireland.)

The disadvantages associated with the use of peat-litter are said to be due to negligence, use of damp litter or of litter of the wrong kind.

I have dwelt at some length on this question because it is not generally understood that the best peat-litter is derived from Sphagnum, and that Ireland is rich in this very material.

In 1872 Dr. D. Moore published an account of his researches on Irish Mosses in the Proceedings of the Royal Irish Academy. In this account nine species of Sphagnum are described as Irish. In "The Flora of the north-east of Ireland, 1888," by Stewart and Corry, four additional Irish species are recorded. Some of the species are now considered sub-species or varieties, and the number of Irish Sphagnums is now nine species, five sub-species (and varieties). The following table is compiled mainly from the records of the two works just mentioned, and may prove useful as indicating the present known distribution of the Irish Sphagnums.

The key following the table is an adaptation from that given in "British Mosses" by H. N. Dixon and H. S. Jameson, to whom I am indebted for figs. 2 and 3.

IRISH SPHAGNACEÆ.

Genus **SPHAGNUM**.

DISTRIBUTION.

A. Cymbifolia.

1. *S. cymbifolium*, Ehrh. Frequent.
   Sub-sp. *S. papillosum*, Lindb. Not uncommon. N.E. Ireland.
2. *S. Austini*, Sull. Very rare, King's County.

B. **Truncata.**

3. *S. rigidum*, Schp. Rare.
4. *S. molle*, Sull. 0. Type not found in Britain.
   Var. *Muelleri*, Schimp. Very rare.

C. **Subsecunda.**

5. *S. tenellum*, Ehrh. Rare.
6. *S. subsecundum*, Nees. Not common.

D. **Acutifolia.**

7. *S. teres*, Angsti. (Not Irish).
   Sub-sp. *S. squarrosum*, Pers. Frequent.
8. *S. acutifolium*, Ehrh. Frequent. (The most variable of all species.)
   Var. *B. rubellum*, Russ. (*S. rubellum*, Wils.) Not unfrequent.
   Sub-sp. *S. Girgensohnii*, Russ. (*S. strictum*, Lindb.) Rare (?).
9. *S. fimbriatum*, Wils. Rare (?).

(10. *S. Lindbergii*, Schimp. Not Irish).

11. *S. intermedium*, Hoffm. (*S. recurvum*, P. Beauv.) Very rare.
12. *S. cuspidatum*, Ehrh. Frequent.

Key to SPHAGNUM,[1] **Dill.**

The only genus.

1. Branch leaves broad, cucullate, scaly at back of apex (2).
   „ leaves not scaly at apex, rarely cucullate (4).
2. Plant green or purple; cells with smooth walls, *S. cymbifolium* (fig. 2).
   „ ochraceous; cell-walls papillose (3).
3. Papillæ very small, conical; chlorophyll cells in section oval or cuneiform (*S. papillosum*).
   Papillæ long, linear; chlorophyll cells in section broadly triangular (*S. Austini*).

---

[1] Species not italicised are not recorded for Ireland. Specimens of the species of *Sphagnum* are available for examination in the Herbarium of the Science and Art Museum.

4. Stem leaves widest at the broad, strongly fringed apex (5).
   „ leaves wider at base or at middle than at apex (6).
5. Stem leaves fringed at end and sides of the rounded summit (*S. fimbriatum*).
   „ leaves fringed only across the truncated apex (S. Lindbergii).
6. Hyaline cells of branch leaves short, two or three times as long as wide; retort cells of branches very large; stem leaves rather broadly bordered (*S. tenellum*).
   Hyaline cells many times as long as wide; retort cells smaller (7).
7. Stem leaves with narrow border, not or scarcely wider below (8).
   „ leaves with broad border, widened towards base of leaf (12).
8. Stem leaves lingulate, very obtuse, fringed at summit (9).
   „ leaves oval or lanceolate; more or less pointed (10).
9. Stem cortex of three or four layers; branch leaves recurved at apex only (S. teres).
   „ cortex of two layers; branch leaves recurved from middle (*S. squarrosum*).
10. Stem leaves faintly bordered, fibrose, coarsely toothed at apex (S. molle).
    „ leaves strongly bordered, finely toothed or erose at apex (11).
11. Stem cortex in one layer only (*S. subsecundum*).
    „ cortex in two or three layers (S. laricinum).
12. Stem leaves very short, rounded, fringed at apex; branch leaves oblong, very obtuse (*S. rigidum*).
    „ leaves longer; branch leaves tapering to narrow points (13).
13. Chlorophyll cells free on dorsal surface; pores small; branch leaves flattened and undulated when dry (14).
    „ cells free on ventral surface; pores large (15).
14. Pendent branches concealing stem; stem cuticle indistinct (*S. intermedium*).
    „ branches none or few; stem cuticle distinct (*S. cuspidatum*).

15. Plant reddish; stem leaves pointed or rounded, usually toothed (*S. acutifolium*).
„ pale; stem leaves truncate, fringed (*S. Girgensohnii*).

THE EXTRACTION OF ALCOHOL FROM TURF.[1]

1. Kappesser, in 1891, took out a patent for a "Method of obtaining sugar-containing fluids and alcohol from turf.".

By this method 1000 kilogrammes of dry turf gave 62–63 litres of alcohol.

2. Berkhahn further examined samples from different layers and from scarcely altered turf-moss (Sphagnum):

	C.	H.
Sphagnum, ...	47·40 per cent.	5·43 per cent.
Upper turf-layer (I.), .	49·24 „	6·61 „
Middle turf-layer (II.), .	53·15 „	5·81 „
Lower turf-layer (III.), .	53·81 „	5·41 „

This shows, as von Feilitzen found, that the percentage of carbon increases with the depth of the bog. Berkhahn obtained the following percentage of absolute alcohol from dry turf:—

Sphagnum.	Turf I.	Turf II.	Turf III.
1·0 per cent.	0·6 per cent.	0·58 per cent.	0·065 per cent.

3. Dr. H. von Feilitzen and B. Tollens further determined, by fermentation investigation, the greatest possible quantity of alcohol in turf ("Journal für Landwirtschaft," 1898, Heft. I.) They found 3·63 per cent. alcohol from turf-litter, at the ordinary T° of the room, 4·84 per cent. at the optimum fermentation T° of 28° to 30° C.

The percentage of alcohol increases with the decrease in the degree of decomposition of the turf.

As the source of the alcohol is the starch and cellulose of the Sphagnum leaf and stem, the quantity of alcohol obtained naturally decreases as the Sphagnum becomes more and more decomposed.

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[1] M. Jablonsky, "Mit. d. Ver. z. Förd. d. Moorkultur im Deutschen Reiche," 1. Jan. 1898.

DESTRUCTIVE DISTILLATION OF PEAT.

There are various ways of carrying out the distillation of peat. The charcoal obtained is very friable and porous, is easily kindled, and has a high calorific power. It is recommended for use in gas furnaces, partly because its ash is so powdery. It is considered not the best charcoal for metallurgical purposes. Attempts are being made to utilize it in the manufacture of calcium carbide for the production of acetylene gas.

In the distillation of peat there are many products obtained. One of these is "Sphagnol," an aromatic mixture of creosote and other products introduced into a soap which is described as useful for the cure of skin diseases.

Through the kindness of Mr. J. M'Meadows, a series of stages in the purification of the products of peat as carried on by an Irish Company of thirty or more years ago, presented by him to the Museum, were shown as follows:—

1. Peat tar product.
2. Crude peat oil from one distillation of tar.
3. Crude peat oil as treated for distillation of the oils.
4. Illuminating oil on distillation of No. 3.
5. Lubricating paraffin oil on continuing the distillation of No. 3.
6. Lubricating paraffin oil with excess of crystals of solid paraffin, showing their formation.
7. Lubricating paraffin oil with crystals removed by filtration.
8. Commercial peat paraffin oil for lubricating.
9. Solid paraffin in the compressed state.
10. Paraffin grease remaining after distillation of lubricating oil.
11. Peat pitch.

TURF-BOG SUBSTRATUM, ETC.

Vivianite has been found, especially after draining, in several bogs in Ireland, and consists of the disintegrating bones of the Irish elk, etc. It is naturally rich in phosphates and lime.

Bog iron ore is an important bog product, and appears to have a future before it. Elsden, in "Applied Geology," just published, gives an interesting account (p. 78) of the mode of formation of bog iron ore from the silicates of iron in the minerals of the rocks in the neighbourhood by the combined action of the carbonic acid, humic acid, etc. of the decaying vegetable matter. The presence of much phosphorus and other impurities may reduce the value of the bog ore. As yellow ochre or limonite, bog ore is used in gas purification, and for other purposes.

The bog clay is, in some countries, largely utilised in brickmaking. This is especially the case in the Netherlands, where the black or factory turf is used in the brick-kilns. Koller states that in Holland and Belgium different experiments with very favourable results have been made in utilising dug-out peat ponds for fish. In making the pond, it pays well to use the mostly clayey subsoil in making bricks, baking the bricks with the peat from the bog. One case is quoted in which the return was 54 per cent.

THE FIBROUS OR INTERMEDIATE TURF.

Between the Sphagnum and the black turf comes the intermediate or fibrous turf, the character of which is largely dependent on its state of decomposition and on its origin. If it is the remains of a former forest, overcome by the encroachments of a peat-bog, tree-roots, &c., will be found in it abundantly, a common feature in Ireland. If it has not originated from an ordinary high peat-bog, or from a morass, the tree trunks may be absent or confined to the edge of the bog, and the peat may consist of Sphagnum and a number of plant-remains, such as Eriophorum, Erica, Vaccinium, or of Hypnum, rushes, sedges, etc.

This fibrous peat is now utilized in quite a number of ways, adding largely to the economic value of a bog. It is in connexion with the utilization of fibrous peat that so much has been done by a happy combination abroad of chemist, engineer, and botanist. The machinery employed has been greatly improved, and skilled labour, so readily available abroad, has been largely utilised.

Fibrous peat-litter.—A great deal of fibrous peat-litter is now made by machinery, to be used in stables, &c. It is not so good as true moss-litter.

Peat-wool, now so much used abroad, in the proportion of 75 parts of peat-wool to 25 parts of sheep's wool or of cotton, in the making of such cloth as is here shown, is mainly, as far as I have examined it, disintegrated cotton-sedge or Eriophorum, a most plentiful plant in Irish bogs. The same plant is the main source of the peat surgical dressing, now in many cases replacing cotton-wool.

Eriophorum is a common enough bog-plant (fig. 5) in Ireland, and there is no doubt but that there is an enormous amount of such raw material available in Irish bogs for the manufacture of good peat-litter. Carpets, roofings, &c., are also made from such peat-wool. If not equal to Brussels, they are at any rate better than mother-earth, or bare rock for a cabin floor. The raw material is sold at about 20*s.* a ton.

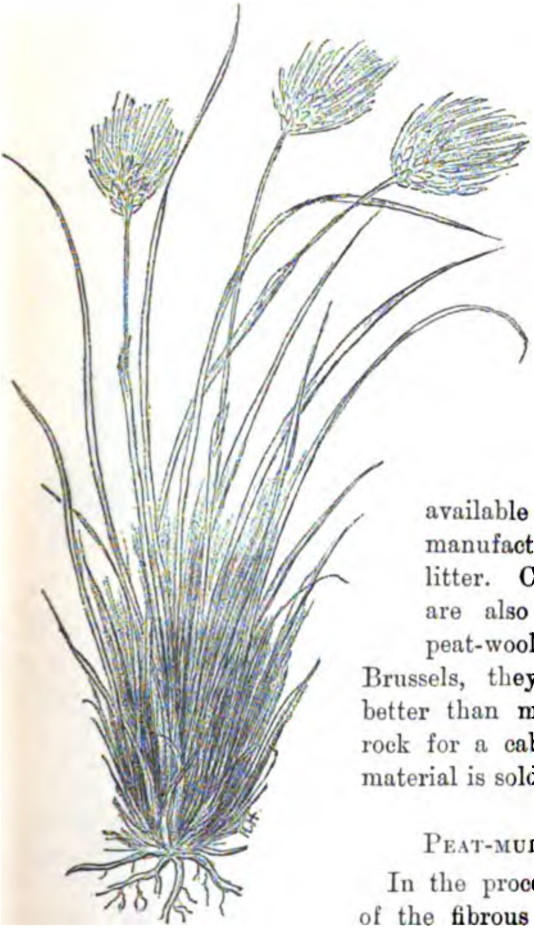

FIG. 5.[1]—*Eriophorum* (Cotton Sedge, or Cotton Grass).

PEAT-MULL, OR POWDER.

In the process of disintegration of the fibrous peat to form peat-fibre, there is a great deal of small powdery peat made (fig. 6). This is known as turf-mull or powder, is now used in making fire-lighters or briquettes (mixed with coal-dust and saw-dust), or is used in dry closets, and for other sanitary purposes. It is also used for various insulatory purposes. It has been found a useful article for fire-proof roofs, &c.

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[1] This figure was drawn by Miss H. Hughes.

I noticed at the recent Royal Dublin Society's Winter Show that no attempt had been made to utilise either peat-litter or peat-mull for packing eggs, though both are highly recommended for the packing of eggs, fruits, &c. I am told it was there, but not as conspicuously exhibited as it deserved to be. One of the most interesting uses to which peat-powder has been applied abroad has been in making the cattle food called peat-molasses powder, of which one German firm advertises a yearly turn-over of 1,000,000 cwt. (Amongst the exhibits were two samples of this fodder.) There is now a good deal of information available as to its value. (See Parliamentary Report C. 8278-13, 1*d.*)

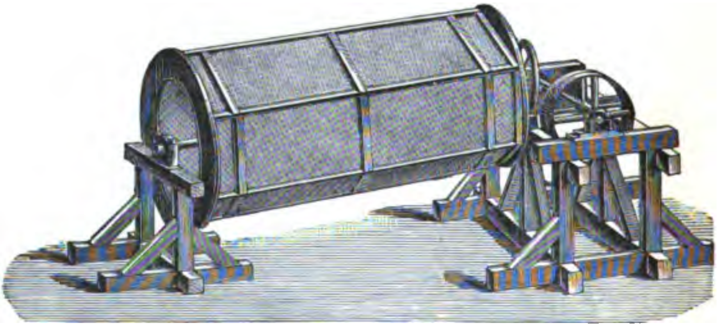

Fig. 6.[1]—Sieve for separation of Turf Powder.

Molasses alone is objectionable as fodder for cattle in that it causes severe purging. Mixed with peat-litter, got by the "Wolf" disintegrating machine from "Sphagnum-Eriophorum" turf, this tendency is more or less completely prevented. The fodder has now been on trial long enough to show that it is a good, cheap food. It must, however, be made from good peat and sound treacle. Although its manufacture on the farm is cheaper, it is, Koller amusingly suggests, better to buy it ready-made, and leave the suppliers to guarantee its goodness.

The advantages of the use of peat-molasses fodder are now more or less well established:—

1. It is 50 per cent. cheaper than the best fat-producing food. It is said by some to be equal in nourishment to such food, but is not so nourishing as wheat bran.

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[1] Figs. 6 to 24 are taken, by permission, from Koller's "Die Torf-Industrie," an excellent work on the turf industry, well worth translation.

2. It tends to keep the animal in health, helps digestion, and whets the appetite.
3. It can replace in part, or be used with bran.
4. It cures colic and other sickness.
5. It gives a healthy, glossy appearance to the skin.
6. Containing so much sugar, it acts as a stimulant, and increases working powers and stamina.
7. Used with care, milch cows give an increased quantity of richer milk.
8. Used for fattening, it increases the weight, and improves the flavour of the meat. This has been noticed in the case of pigs.
9. It lessens the farmer's fodder bill, and by the large amount of alkali present in the molasses provides a good manure.
10. It keeps well.

Much of the information as to the fodder is due to W. Schwarz, in Hanover, and Becker, in the University of Leipzig.

In making the peat-molasses fodder, the molasses is heated to 190° F., and mixed, while hot, with the peat in the proportion of 80 parts of molasses to 20 of peat-powder, or mull. Its cost in Germany is 2*s.* 2½*d.* per cwt., carriage paid.

The molasses used is a bye-product in the beetroot sugar industry.

Weigmann gave nine cows each day 3 kilogrammes (nearly 7 lbs.) each of peat-molasses fodder in place of 3 kilogrammes of wheat bran. There was no perceptible change in the quantities of milk and food, and no interference with the general health of the cows. Profs. Märker and Albert speak highly of the fodder. In some animals dissected no inflammation of the intestines or accumulation of turf was observable, though the feed had contained as much as 8 lbs. of the peat-molasses fodder. As Koller says, it is going too far to say as Märker does that one may give the animal any amount of this fodder. Most animals take to the fodder very readily. In all cases small quantities should be given at first, and the animals' food should be varied. Pachlig, director of a dairy school, after experimenting with more than 100 animals, recommends the giving to older swine, without injury to their health, of 2½ kilogrammes of peat-molasses fodder per 100 kilogrammes of their weight. Favourable reports on every kind of animal are given, including sheep and young animals.

Koller states that a thorough investigation of the physiological effect of turf has not yet been made, and he is strongly opposed to an unlimited use of the peat-molasses fodder. He recommends as a maximum for average weight animals per head per day the following:—

Oxen for fattening, . .	5	kg.	=	11	lbs.
Yoke-oxen, . . .	2½	,,	=	5½	,,
Half-bred horses, . .	1¼	,,	=	2¾	,,
Milch cows, . . .	600	gr.	=	1⅜	,,
Full-grown pigs (for bacon),	600	,,	=	1⅜	,,
Sheep for butcher, . .	250	,,	=	½	,,
Sheep for the market, .	120	,,	=	¼	,,

Koller thinks it better to give to the fattening oxen rather less than the above quantity. He does not recommend it for valuable breeding animals, or for young cattle, and is strongly opposed to giving it to well-bred, especially thorough-bred English horses, and to pregnant animals.

The fodder keeps well, especially when spread out like corn, in the corn-loft. It does not readily "heat." Keeping it in bags is not altogether to be recommended.

The peat-powder in the fodder is not simply a convenient vehicle for holding the treacle; but, by the influence of its humic acid, and the resinous, wax-like bodies, it neutralises the purging tendency of the potassium compounds and the volatile acids in the molasses.

Pigs, it seems, recognise the constipating tendency of peat, and, when suffering from diarrhœa, eat it instinctively. Horses are sometimes similarly cured. There are, however, cases known in which turf litter has been eaten by animals, and has caused their death, owing to the inhibitory effect upon the digestion, of the tannin and other organic substances in the turf.

PEAT POWDER AS A GERMICIDE.

Stutzer and Burri investigated the effect of turf mull or powder on the cholera and typhus bacteria,[1] and found that, while ammonium carbonate favours the development of the cholera bacillus, the mixing of turf-powder with the fæces must add so many acids as to kill not only the cholera bacillus, but also those bacteria which are capable of extracting ammonium carbonate from urine. C. Fränkel and E. Klipstein[1] found that sterilised peat killed off the germs of cholera and of typhus bacilli in a few hours, but when urine was added they were still living at the end of fourteen days, the typhus germs being generally more resistant.

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[1] Zeitschr. f. Hygiene, 1893.

GROWTH OF BOG IN THICKNESS.

This is naturally dependent on the nature of the flora, and in some cases the bogs increase in thickness each year 5 or 6 inches, in some cases not at all. This process of growth must not be overlooked, especially in districts where peat-fuel is scarce and it is necessary to make provision for a renewal of peat beds. Cases are known in Ireland where islanders, neglecting this precaution, are now without any peat.

This increase in thickness by growth must not be confounded with the increase in thickness of the bog by absorption of water.

The arching of the bog is due to a combination of the two causes. The high peat bog starts at its highest point, and spreads from it in all directions, the difference in level of the highest point and the margin from which water tends to flow on to the surrounding land being sometimes as much as 33 feet, according to F. Gayer.

A Sphagnum forms its large patches, not by the formation of fresh plants from its spores, but by a process of innovation. Branches arise on the main stem and grow to be more or less like the parent stem. The stem common to the two decays and two independent plants are formed. By closely crowding together the plants remain vertical in the tufts. There is thus growth and renewal at the surface of the bog, decay proceeding below the surface. On examining a turf-cutting in the bog, signs of this descending decay are evident, affecting the Sphagnum and all the other plants found growing at the surface.

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[1] Zeitschr. f. Hygiene, 1893.

As just mentioned, in connection with the manufacture of alcohol there is in an ordinary decomposing bog, a gradual increase in the percentage of carbon and decrease in that of hydrogen and of oxygen present in the turf.

I do not propose to enter into the chemistry of the question. Those interested will find an account on the subject, still very much in need of investigation, in a recently published work on "Cellulose" by Cross and Bevan, from which the table here given is taken. The decay of the dead parts of the plant cast off from the living plants is partly complete—into carbonic acid and marsh gas by the agency of bacteria—and partly incomplete, or peat, as such, naturally would not occur. In this latter case the tendency is just the opposite of the first, being a tendency towards condensation of the carbon nuclei to more highly complex forms, with a splitting off of water, a process which results in the formation of peat, lignite, and coal from plant remains.

	Oak Wood.	Humus, from Decayed Oak.		Peat, Dartmoor.
C, . .	50·20	54·0	56·0	59·73
H, . .	6·08	5·1	4·9	5·91
O, . .	43·74	40·9	39·1	31·82
N, . .	—	—	—	2·54
Approx. formula (C,H,O),	$C_{34}H_{48}O_{22}$	—	—	$C_{20}H_{22}O_8$

COALS.

	Scotch.	Wigan, Cannel.	Anthracite.
C, . . .	78·46	82·39	91·87
H, . . .	8·11	5·68	3·33
O, . . .	13·73	8·31 2·18	3·01 0·84
Approx. formula (C,H,O),	$C_{25}H_{32}O_3$	$C_{26}H_0O_2$	$C_{40}H_{16}O$

As Cross and Bevan state, the process is similar to that which occurs in the artificial retting of flax. "In proportion as the celluloses are attacked by destructive agencies, the residue tends to constitute itself into a complex of increasing resistance; and so the chemistry of the vegetable world, which depends in its proximate relationships upon the properties of polyhydroxy derivatives of the C unit, is ultimately a most striking manifestation of the properties of the carbon atom itself."

This progression of decay is readily seen in a bog-cutting. At the surface, we have the more or less green living plants, below this the beginnings of decay and plant humus, lower still the yellowish brown peat in which the decaying Sphagnum is accompanied by the decaying stems, leaves, and roots of such plants as were earlier growing at the bog surface. This is the *fibrous* or *brown peat.* Still lower comes a stratum of *amorphous* or *black* or *factory peat* in which the plant remains may not be recognisable as such. This may be more or less dense and compact, pressure, oxygen, water, and other agencies having played their part in its conversion. Below this may be a further stratum of black, less compact, more liquid turf, *dredged peat*; the bottom of the bog being clay, sand, &c.

PROPORTION OF WATER IN PEAT.

In fresh peat, water may form 90 per cent. by weight of the peat. Air-dried turf contains 15 to 30 per cent. of water. [This large amount of water and the great shrinkage peat undergoes in air-drying was illustrated by a model and turf clod. When first taken out of the bog and broken up, the intermediate turf filled the model; the clod became only one-fifth of its size, with, Prof. Barrett found, a sp. gr. of 1·025. It approached in character the factory or black turf.] Although continental authorities insist on the necessity of draining a bog before attempting to utilise it for peat-litter, fuel, or other purposes, drainage[1] is, I believe, in Ireland, not as general as it should be. It is scarcely necessary to say that peat litter, not freed as much as possible from the bog-water it naturally holds, is less serviceable than drain-dried peat-litter. Further, one objection to peat as fuel is the large amount of water air-dried peat contains, wasting in its conversion into steam a large amount of the heat generated by the burning peat. The more water the peat holds when dug out, the longer the time it takes to dry.

It is in connection with the treatment of the intermediate or yellowish brown peat and the black peat that continental workers have made such advances, partly in the direction of improving and cheapening of the machinery, partly in the development of numerous new industries.

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[1] Here, at Knockboy, Connemara, where I am correcting the proof, the Congested Districts Board has supplied a splendid object lesson in bog drainage.

THE MANUFACTURE OF PLASTIC SUBSTANCES FROM FIBROUS TURF.

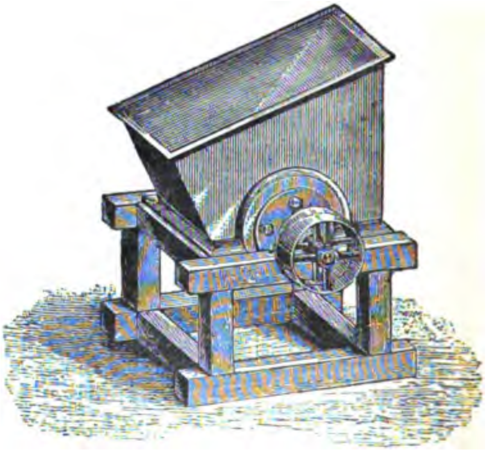
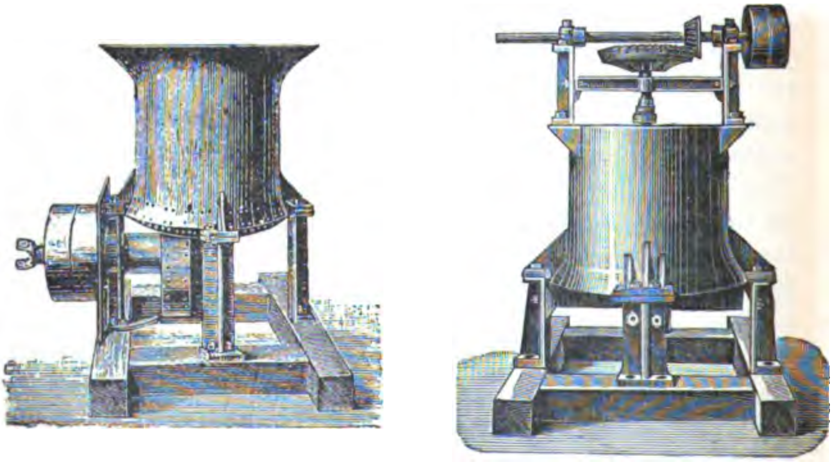


FIG. 7.—The "Wolf" Disintegrator.

The manufacture of plastic material from turf has a distinct practical significance, and is regarded as capable of still further development. Plastic material has its own special use as such. It is also of importance in replacing other more expensive material, both external and internal characters being of importance. As a cheap material, combined with cheap binding material, capable of serving definite practical requirements and objects, turf has been successfully tried by Gercke. He took the upper layers of turf, consisting of a fibrous, spongy mass, and, after drying it, pressed it strongly together. (Samples were shown.) When used for roofing, the plates so got are soaked in a warm mixture of tar and asphalt, or soaked with plaster of



FIGS. 8 and 9.—Turf Litter Mills.

Paris, dried, pressed, and then covered with silicate of soda. As this pressed turf can be sawn, perforated, cut, polished, and coloured, it is considered a suitable substitute for papier-maché, paper material, wood, horn, bone, &c. The preparation of the material is quite simple. Additional firmness is given to the material by introducing into it such substances as bast, tow, twine, long turf fibres, heather, metal, and wood refuse. Ornaments of all kinds, vessels, cardboards, patterns can be made out of the prepared raw material, the applicability of which is increased by treatment with steam. Its great cheapness, easy and simple acquisition and preparation, its lightness, homogeneous structure, are all features in its favour. Its firmness and density too can be varied as desired. Heimann has made artificial stones or blocks from this plastic turf material. Turf, drained and dried, is mixed with 15 to 25 per cent. of the iron-containing refuse of aniline manufacture, put into a boiler, and softened by heating. The mass is subsequently subjected to pressure, and gives a substance which can be used as asphalt for street paving, and for the soles of boots.

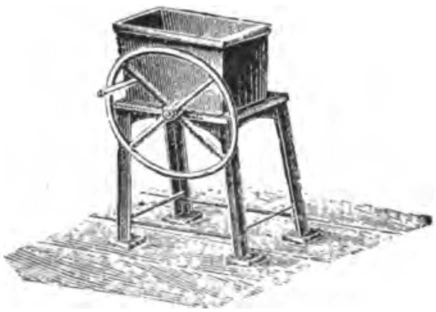


FIG. 10.—A Hand "Wolf" Disintegrator.

Artificial wood has been made by Geige by the aid of plaster of Paris and hydraulic pressure, which almost destroy its hygroscopicity. After becoming dry, the mass is oiled or coated with a solution of resin in spirit. The following proportion of the parts is recommended:—

2 parts by volume of plaster of Paris.
10–12 „ „ water.
6–8 „ „ turf.

In making the mixture on a large scale, a little lime is added to expedite the binding together of the constituents.

Artificial wood so prepared is resistant to heat, cold, and pressure, and can be worked.

Peat is also made into coverings for hot-water pipes, boilers, &c. Peat is also used for walls or partitions on ground which is too soft to bear much weight. The gaps which arise by shrinkage can be prepared for by directing their course by making depressions in the outer plaster on the wood framework, filling them in on occurring. The plaster adheres very firmly to clean peat, containing little humic acid. On account of its elasticity, turf-litter or peat-moss can also be used for the manufacture of pasteboard, felt, or wadding. It can, when freed from earthy matter, completely replace rags in the manufacture of roofing pasteboard (carton-pierre), the colour of the turf being no obstacle.

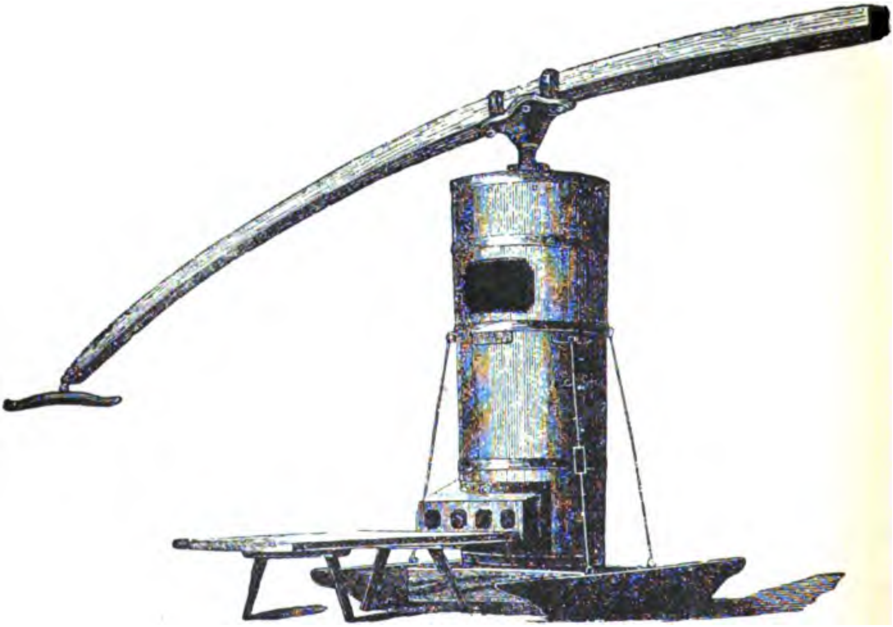


FIG. 11.—Horse Turf-Press.

It is considered that the application of turf to the manufacture of plastic materials is by no means exhausted.

The chief expense in the conversion is the pressure. Where this is not costly, the manufacture is remunerative, and the question now is not so much the making of the material as the utilisation by commerce of its products.

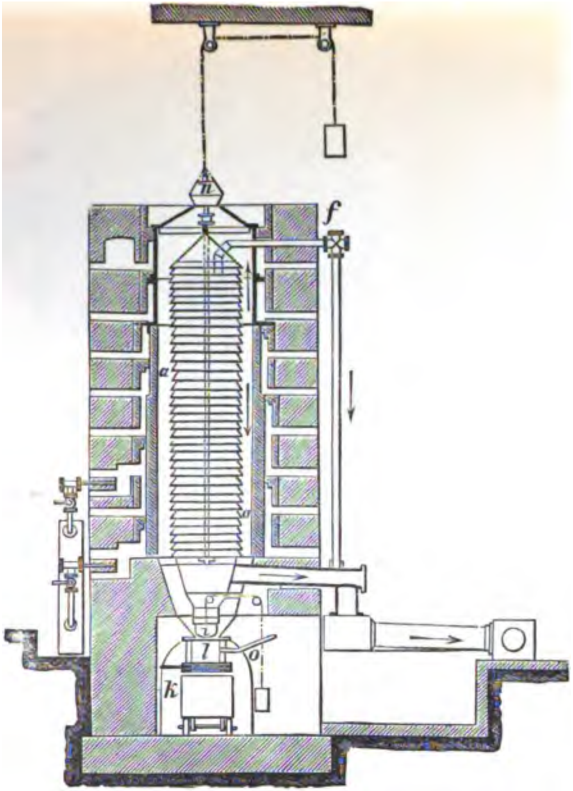


Fig. 12.—Apparatus for Impregnating Turf.

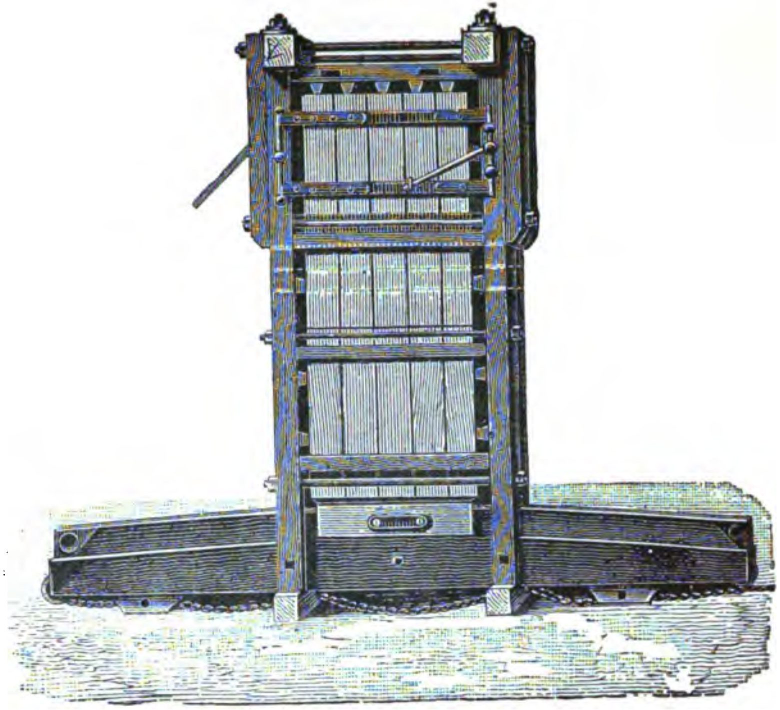


Fig. 12*a*.—Upright Press for preparation of Turf Litter Bales.

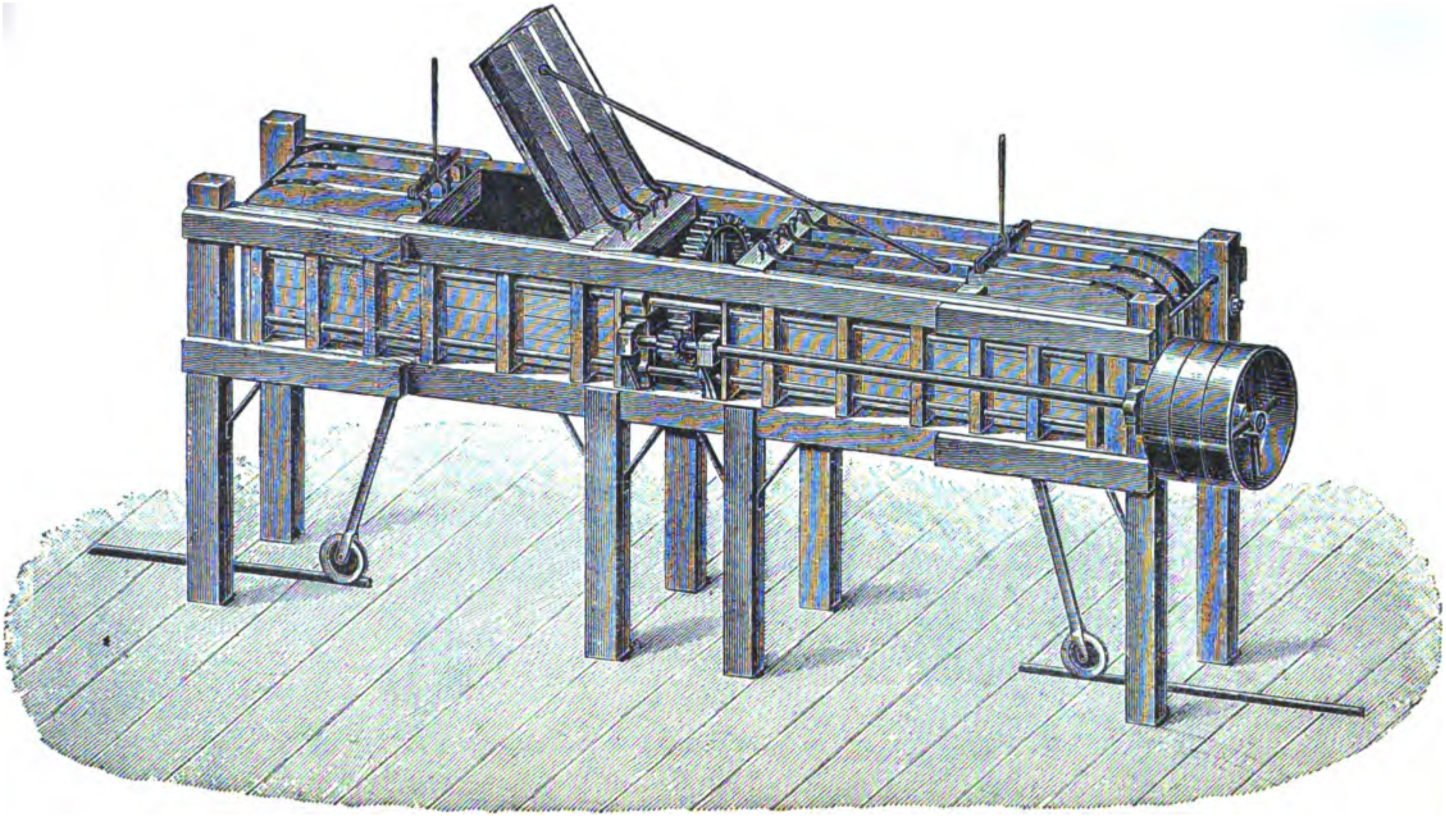


Fig. 12*b*.—Horizontal Turf Litter Press, with double action.

PEAT AS FUEL.

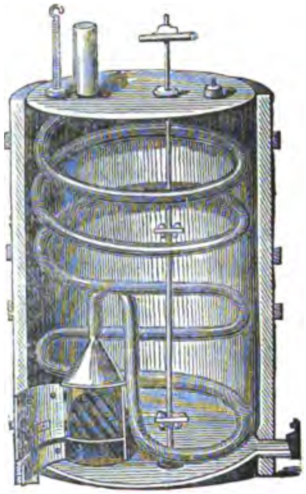


FIG. 13.—Calorimeter.

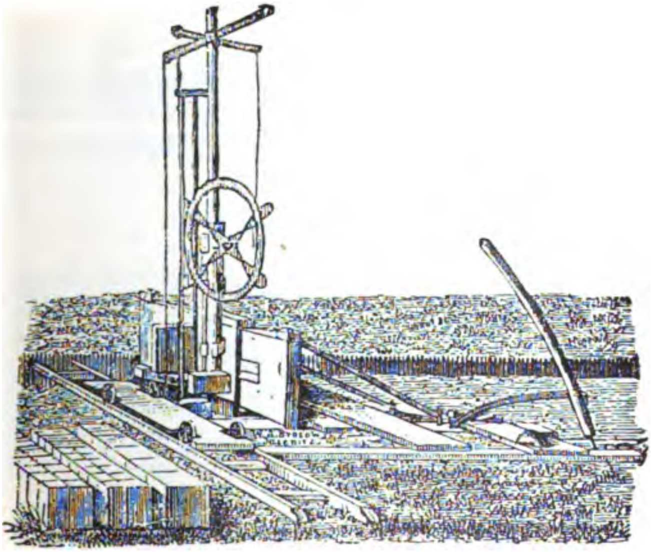


FIG. 14.—Turf-cutting Machine.

The three chief drawbacks to peat as fuel are its bulkiness and the large amount of water and of ash it contains. Ordinary air-dried peat does not pay its way in Germany by rail for more than twenty miles. The amount of ash varies considerably, being partly dependent on the introduction of solid matter by inundations, &c. Ordinary air-dried turf has about half the heating power of good coal, and it is roughly estimated that two tons of peat are equal to one ton of coal, and ought not to cost more than half as much as coal, assuming each fuel is equally available. The following table is taken from

"Thorpe's Dictionary of Applied Chemistry," and shows the relative heating power of the different substances:—

	Calories.
Air-dried wood, with 20 per cent. H_2O,	2800
Dry Charcoal,	7050
Peat, with 20 per cent. H_2O,	3600
Dried peat,	4800
Peat charcoal,	5800
Average bituminous coal,	7500

According to J. Head, the evaporative values of these substances, when burnt in a tubular boiler, compare as follows:—8 lbs. of water will be evaporated by 1 lb. of good coal, by 2 lbs. of dry peat, 2·25 to 2·3 lbs. of dry wood, 2·5 to 3 lbs. of cotton-stalks or

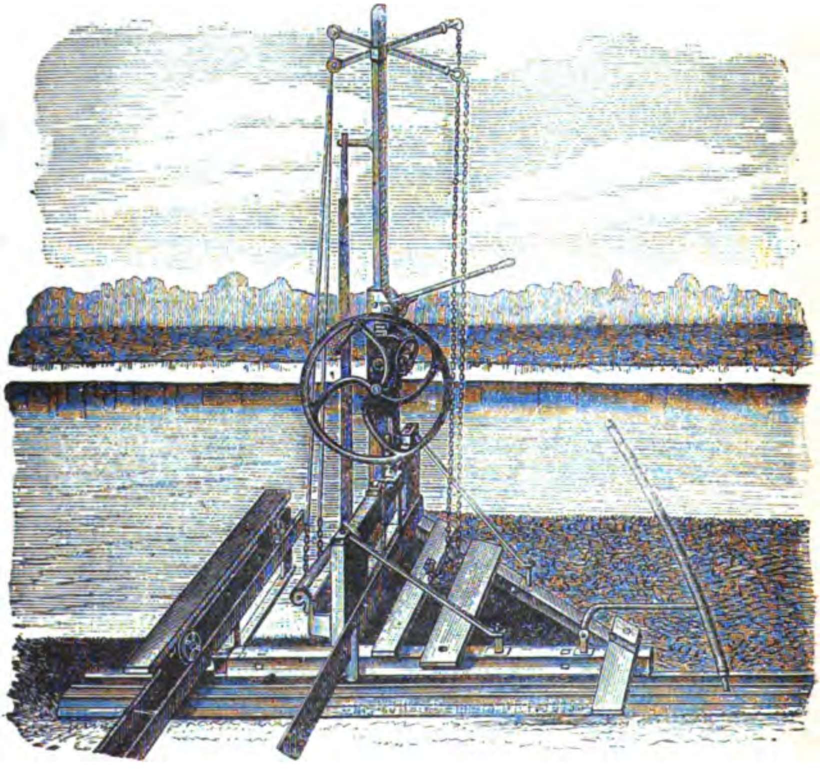


FIG. 15.—Turf-cutting Machine.

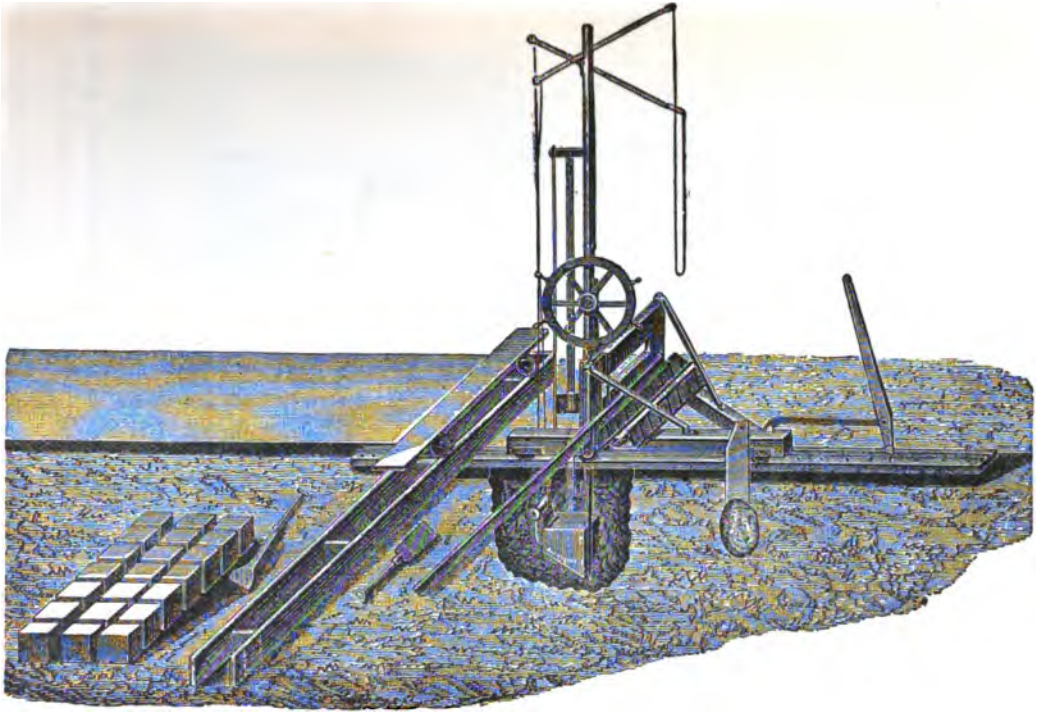


FIG. 16.—Turf-cutting Machine.

brushwood, or 3·25 to 3·75 lbs. of straw. Captain Abney, C.B., F.R.S, expressed to me the opinion that the determination by calorimeter of the calorific capacity of a substance was not always the most satisfactory way of ascertaining its value as a fuel—that *the time* a given quantity of fuel took to bring a given quantity of water to boiling point was often a better test. I am told that from this point of view the manufactured peat-fuel compares, when not too densely made, very favourably with coal.

Of recent years various methods and machines have been tried with the object of increasing the value of peat as fuel, and for manufacturing purposes. To compete with coal, peat sods or turves should possess—

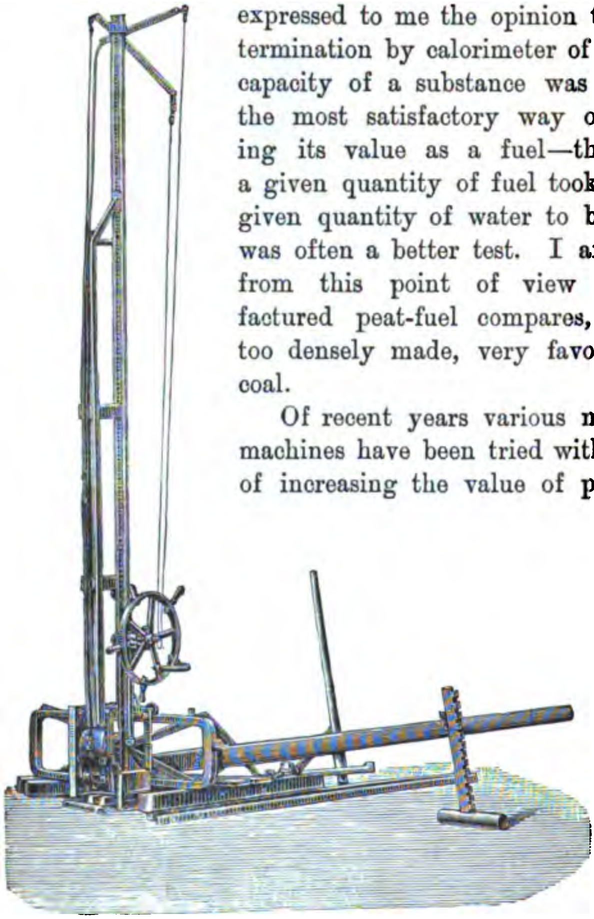


FIG. 17.—Part of Turf-cutting Machine.

1. Density (as uniform as possible).
2. Compactness (not lost in burning).
3. High combustible power, especially possessed by the black, amorphous, factory turf.
4. Dryness throughout the turves, including loss of hygroscopicity.

5. The quantity available should be abundant and constant, and the cost of production should not be prohibitive. Contraction, dry pressure, wet pressure, destruction of structure, with or without pressure, have all been tried.

The methods now adopted involve the destruction of the fibrous structure of the turf, and the application of only a moderate pressure, if any at all.

The illustrations give an idea of some of the methods of breaking up the fibrous or other peat, and of subjecting it to pressure, before making the turves, to be subsequently more thoroughly dried. In these methods the valuable humus carbon is not lost.

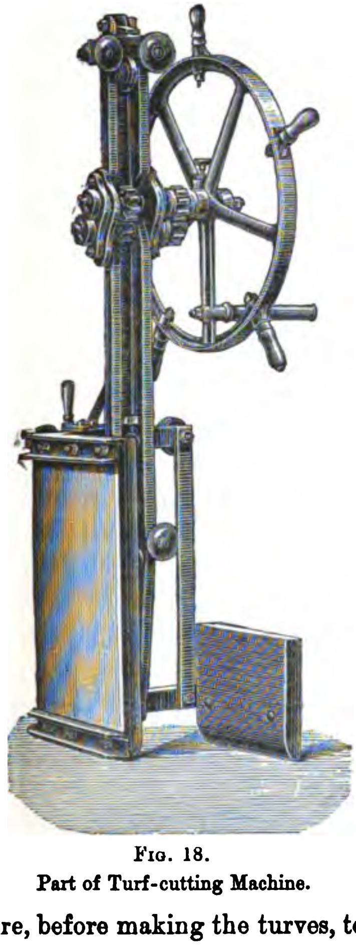


FIG. 18.
Part of Turf-cutting Machine.

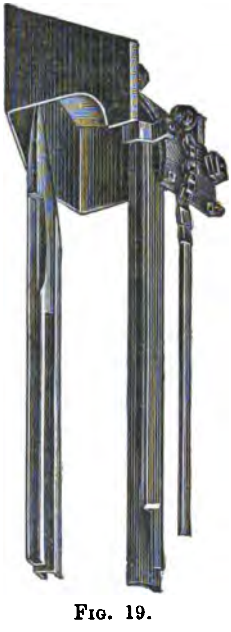


FIG. 19.
Part of Turf-cutting Machine.

1. In Schlickeysen's method, steam-power is employed. In twelve hours 30,000 turves are made, which dry quickly in kilns, and are used for glass and porcelain manufacture.

2. Geysser's method is worked by hand. The principle is the same as in Schlickeysen's method. 2500 to 3000 turves a day can be made on the bog, no fuel being used. It is not workable with very fibrous peat. The turves are dried on hurdles, one above another, and roofed.

3. In Grotjahn-Pilau's method (Krauss & Co., of Munich, makers of the machinery). On a similar principle to that of Schlickeysen; the macerating machine is horizontal.

(Specimens of machine-made turves from county Sligo, made by the Blunden process, were shown.)

While one ton of ordinary air-dried turves is worth only one-third or one-half ton of good coal, the machine-made denser turf is worth two-thirds as much as coal; so that three tons of such machine-made turves are equal in value to two tons of coal.

Cost of carriage and delivery must of course always be taken into account. At present the cost of the carriage of a ton of these turves from Sligo to a house in Dublin is greater than the cost, including carriage, of a ton of factory coal from South Wales to Dublin.

Such machine-made turves are capable of welding iron, and may prove compact enough to stand the blast of a furnace for smelting purposes, for which purposes turf is used in Scandinavia.

I think it will be of economic interest if I introduce here a report on the utilization of peat as a fuel in the Siemen's "Regenerative Gas Furnace," by Professor Emerson Reynolds, F.R.S., a report submitted to the Royal Dublin Society as long ago as 1872, when coal, owing to strikes in England, was very expensive.

"ROYAL DUBLIN SOCIETY, KILDARE-STREET.
"*August* 22*nd*, 1872.

"MY LORDS AND GENTLEMEN,

"The utilisation of peat has so often occupied your attention since the publication of Sir Richard Griffith's and other engineers' valuable reports on the bogs of Ireland, and public interest in the subject is now so fully aroused, that I venture to bring under your notice a mode of employing peat as fuel for industrial purposes which appears to have been either overlooked or strangely neglected in this country. The successful and economical use of peat in manufactures is, in my opinion, more likely to depend on the proper adjustment of the furnace to the fuel, than of the fuel to the furnace, the costly preparation of peat being open to many serious objections. In 1862

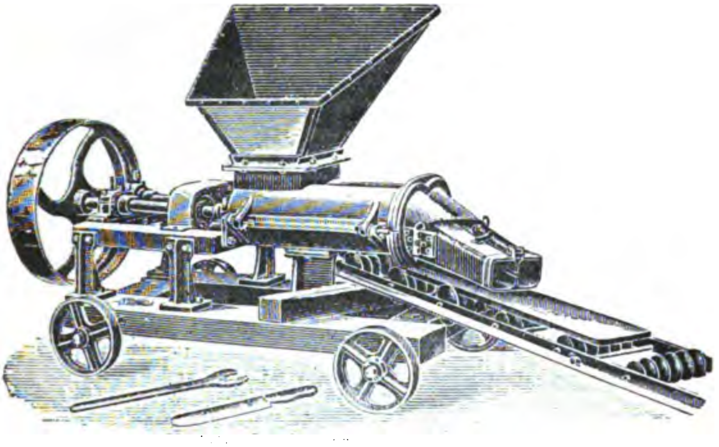


FIG. 20.—New Improved Turf Steam-Press.

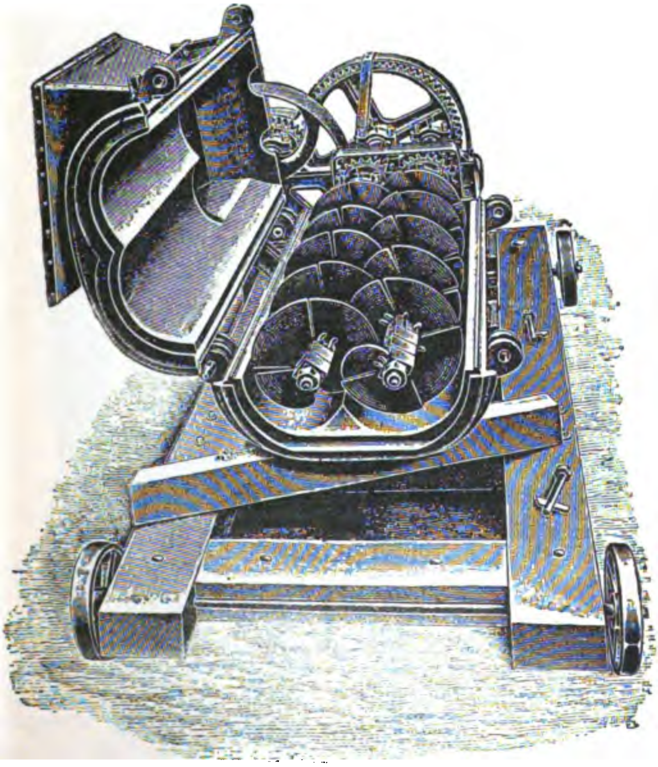


FIG. 21.—Internal view of a Turf-Pressing Machine.

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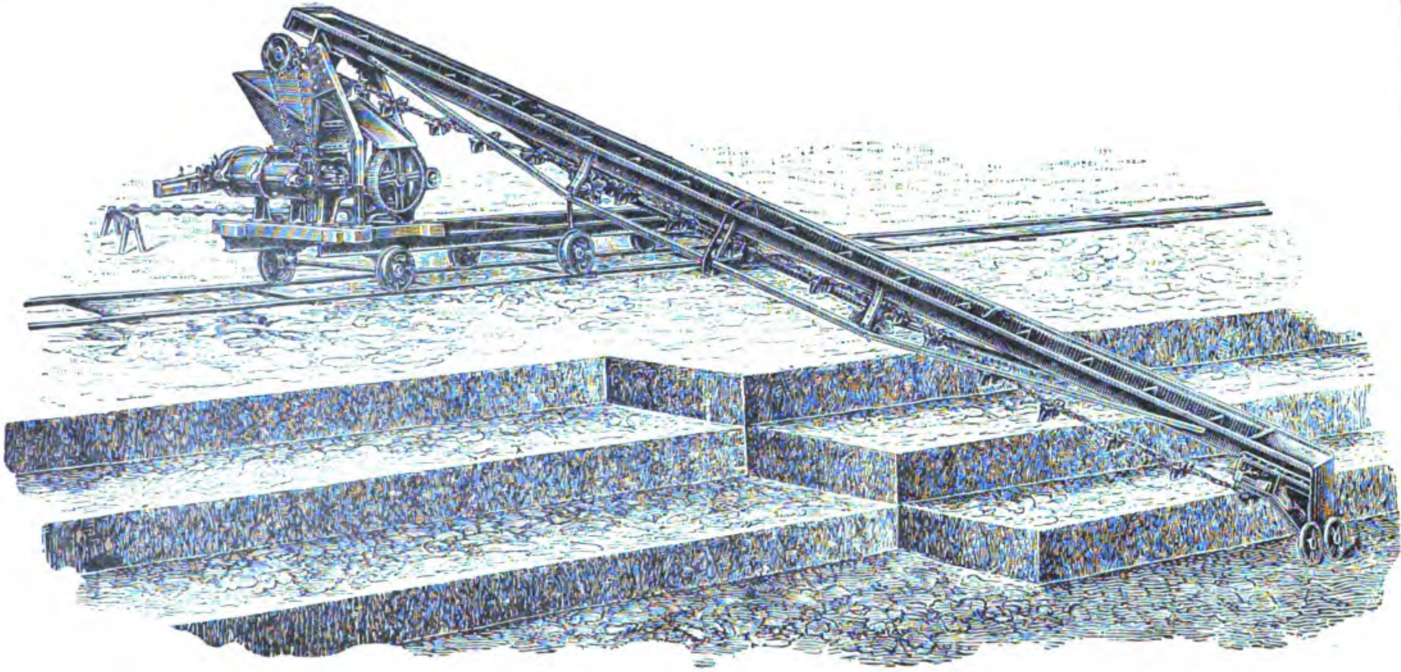

FIG. 22.—Chain Elevator connected with Turf-Press.

the venerable Professor Faraday delivered his last lecture at the Royal Institution of Great Britain, and took for his subject 'Siemen's Regenerative Gas Furnace.' At the time I was much impressed with the admirable apparatus described, in consequence of the facilities it afforded for the combustion of any such bulky fuel as peat, and have since watched with great interest the gradual improvements effected through the costly and laborious experiments of Mr. Siemens. Some estimate of the extent of these investigations may be formed when it is stated that, up to the year 1862, the inventor held two patents for regenerative gas furnaces; but that he has secured eighteen patents for improvements in his apparatus and applications to various kinds of manufactures, including the production of cast steel direct from the ore, of zinc, glass, pottery, &c. I may now briefly describe the apparatus in general terms.

"In the regenerative gas furnace the fuel is very simply converted into combustible gas, in a large separate chamber of peculiar construction; the gas is then conducted into the furnace containing the material to be heated, and then burnt with hot air. After use, the intensely heated products of combustion are made to pass through brick chambers called 'regenerators,' and the heat which would otherwise be wasted is caught, stored up in the bricks, and consequently made to raise to a very high temperature the air, &c., required to supply the furnace.

"It is unnecessary here to enter into details of construction; but I may be allowed to point out that, in addition to the economy of heat resulting from the use of this apparatus, two special and most important advantages are gained. In the first place, a bulky fuel like peat, containing a large proportion of worthless and often injurious ash, can now be easily and successfully employed in several important manufactures, since it is no longer necessary to bring the solid fuel into direct contact with the material to be heated. Secondly, the use of very dry fuel is not required, owing to a peculiarity in the mode of working the furnaces. Considerations of this kind clearly lead to the conclusion that Siemen's apparatus is specially suitable for the combustion of rough and simply air-dried peat. I have now the pleasure to submit a letter lately received from Mr. C. W. Siemens, D.C.L., F.R.S., upon this subject. When it is stated that Mr. Siemens has not only constructed furnaces on his principle in Great Britain and on the Continent, but he has also erected works of his own at Birmingham, in order to perfect the details of his plan on a larger scale, and adapt the apparatus to different kinds of fuel, the value of his opinion can be easily appreciated.

"'3, PALACE HOUSES, KENSINGTON GARDENS, W.
"'*August* 16*th*, 1872.

"'DEAR SIR,

"'In reply to your letter, I have much pleasure to state that you are perfectly right in your opinion that peat simply air-dried is very suitable fuel for my regenerative gas furnaces. I have used it abroad for working glass furnaces, and I have employed it with complete success for making steel in this country. Indeed, the men gave the preference to peat over Staffordshire coal in working the furnaces.

"'In England coal is, of course, the cheaper fuel; but I am convinced that, through the application of peat, as you suggest, several branches of industry may be planted with great advantage in Ireland.

"'Regarding the heating value of peat, as compared with coal, it can be arrived at for my purpose by simply ascertaining the relative percentage of solid carbon in both. The water (if not in excess) may be regarded merely as a deduction, without injury to the heating value of the solid constituents, as would be the case in burning the fuel direct.

"'The vapour of water mixed with the gas is all condensed in the cooling tubes of my apparatus before reaching the furnace.

"'If the peat fields of Ireland should be made available for industrial purposes, you would accomplish a most desirable object, and I would be glad to give you every assistance.

"'I remain, dear Sir,
"'Yours faithfully,
"'C. William Siemens.'

"The adjustment of apparatus to material, of furnace to fuel, has, therefore, been successfully made by Mr. Siemens; and I venture to hope that, through your influence, Irish manufacturers may be induced to utilise the power now evidently at their command.

"I have only to add, in concluding this report, that the specifications above referred to, and working plans of furnaces, &c., are to be found in your patent library.

"I have the honour to be,
"My Lords and Gentlemen,
"Your obedient Servant,
(Signed) "J. Emerson Reynolds."

At that time many efforts, unfortunately not continued, when the price of coal went down, were made to utilise peat more fully as a fuel. It was in connection with these attempts that Dr. Sullivan, Professor O'Reilly, and others got together a large collection of

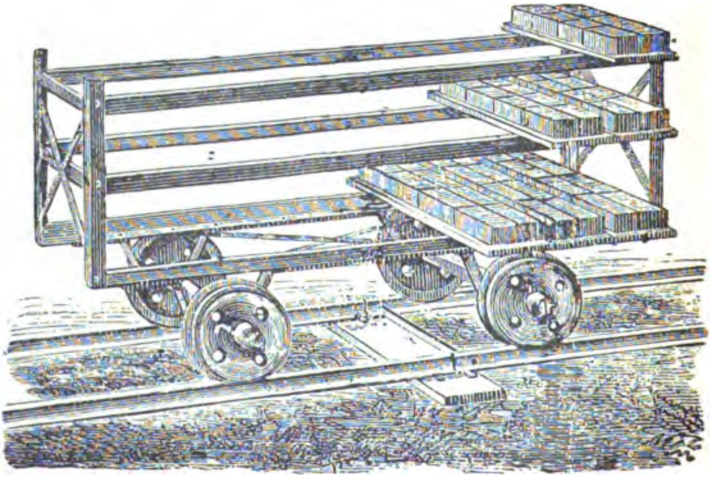

Fig. 23.—Wagon for Transporting Fresh Turf Sods.

Irish turf samples and their products for the Royal College of Science. [Some of these were exhibited.] At this time Messrs. Purdon, M'Meadows, and others paid a visit of inspection to the Continent. The result of their visit is given in the *Farmers' Gazette* for 1872. Mr. G. H. Kinahan, M.R.I.A., contributed articles on the subject to the same Journal.

It appears that the result of using turf on railways, &c., is to prove that boilers and tubes, &c., last five times as long as when coal is used, owing to the comparative freedom of the turf from sulphur. On the stretch of railway, Rosenheim-Salzburg, passing through the Bernau bog in Bavaria, the saving in the fuel bill is said to be £10,000 yearly, part of the saving being due to the turf being cheaper, the greater part to the purity of the turf.

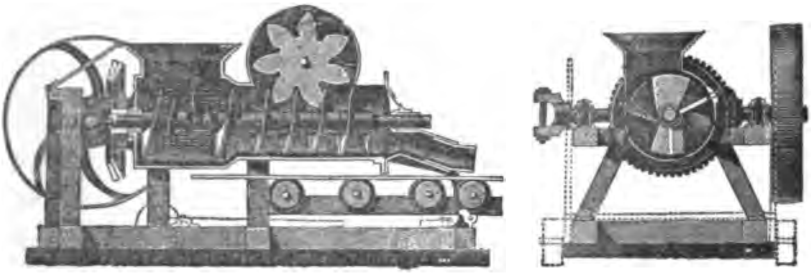

FIG. 24*a*, *b*.—Turf-Pressing Machine (part of).

Part II.—THE IMPROVEMENT OF BOG-LAND.

THERE is at Bernau, on the Chiemsee, some eighty miles south-east of Munich, a large tract of bog-land which has been for nearly ten years past in process of reclamation by the help of the Bavarian Government. During my visit to the experimental station there, which is under the charge of Dr. A. Baumann, I was shown everything that was being done in the investigation of the best methods of improving and cultivating the bog. Some of the results of the treatment were astonishing. I felt the work going on was just the kind required in Ireland. The following account is based partly on documents given to me, partly on verbal communications, and partly on personal observations[1]:—

There exists in Bavaria a Bavarian institution for bog-cultivation, which is endowed by the Bavarian Government, and has set itself the practical and desirable object of making the barren bog of Bavaria, 600 square miles in extent, into fertile fields, meadows, and forests. In the carrying out of this object the institution gives a great deal of help to the bog-owner.

At Bernau, on the raw bog, I saw in course of erection a two-storied house to serve for the accommodation of the investigator, his offices, papers, &c. Round the house bog-land, to serve as kitchen garden and as flower garden, was being marked off, while east of it were the experimental plots to be mentioned later. In another part of the bog was a house for several of the hands. At one end of the bog was a large shed, where were stored in order large quantities of the different kinds of named manures, for sale to farmers in the district. Ploughs, &c., found useful in the cultivation of the bog, were also stored here. Throughout the district, and not simply on or near the bog, were posts carrying large metal notice-boards, on which directions were printed, giving the quantities and prices of the right kinds of manure to use on high and low bogs, &c. I was told these notices were highly valued by the bog-land cultivators.

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[1] Early in this century the Government, with the help of the Royal Dublin Society, published detailed reports, with many maps, of schemes for the drainage and reclamation of Irish bogs (1810–1814).

Dr. Baumann has written a number of reports on the Bavarian bog-lands, from one of the latest of which, "Die Moore und die Moorkultur in Bayern: Die Landes-moorkulturanstalt in Bayern, I., 1898," I shall quote extensively. In some parts my account will be practically a translation.

There are some bogs not worth cultivation, and before cultivating *every bog requires draining and manuring.* Very often, as in all high bogs or sphagnum bogs, the bog surface must be also worked up—burnt, harrowed, ploughed; in some modes of cultivation covered with mineral soil.

DRAINAGE.

The first object is to ascertain the cause of the water-logging of the bog, and this discovered, the removal of the cause must be attempted.

CAUSES OF WATER-LOGGING.

1. Overflow into bog from higher points.
2. Overflow into bog from lower or deeper-lying waters, through penning or flooding.
3. Springs or ground-water in the bog itself.
4. Rainfall and water-holding tendency of bog.

To get at the cause a survey is necessary. This is undertaken at Government expense by the Institution, at the simple request of the bog-owner. Not only is this survey so made, but all the other conditions on which the successful cultivation of the bog depends are similarly carried out by the Government without any expense to the owner.

One feature in an after-effect of drainage has to be carefully allowed for—the shrinkage of the drained bog. After drainage the parts of the bog which project out of the ditches shrink, it may be as much as 1–2 metres (3–6 feet).

It shows itself in the course of years, if the bog-soil has not been covered with earth, but in the mode of cover-cultivation it may occur soon or at once after the earth-covering.

The relation of the bog to its surroundings becomes changed by the lowering of the bog-surface. A bog half a metre (20 inches) above the surrounding land before drainage may become as much below after the drainage, and as a result of the shrinkage the natural drainage is lost—the bog may become again water-logged. Extra expense, only recouped in extensive bog cultivation, is incurred in deepening the drains or in providing artificial drainage by pumps or water-engines.

Hence arises the necessity of gauging the shrinkage, &c. This depends chiefly on two causes:—

1. *The depth of the layer.* The shrinkage is the greater, the greater the layer.
2. *The physical state of the turf.* Looser, little decomposed turf shrinks more; also, pure turf shrinks more than turf mixed with mineral matter.
3. In many cases the living plant-covering exercises an influence on the shrinking of the bog, especially on meadow-bogs overgrown in parts with high moor plants—the Sphagnums, &c.

The meadow parts of the bog decompose more quickly, and collapse more than the Sphagnum parts, which resist decomposition for a longer time. Such bogs become after some time, even if they were previously quite level, hilly or undulating—a feature which becomes more pronounced by covering with sand. In this way the conditions of drainage may become so unfavourable as to render useless any cultivation begun.

4. The bog substratum has also an important effect on the drainage. A bog with a readily permeable sandy substratum needs less drainage than one with an impermeable loamy or clayey substratum.

Ditches for drainage, 40 inches deep, may be 40 to 60 yards distant in a very flat, well-decomposed bog, resting on a very permeable sand.

In deeper bogs the ditches must not be more than half as far apart, and as the thickness of the turf layer increases the ditches must be 6 or 7 feet and more deep.

Both as regards high or sphagnum bogs and meadow bogs there are still many questions to be solved.

Thus in the preparation of a suitable plan of drainage, the following matters must be attended to:—

1. Local investigation of the relations of the natural drainage or water-flow. Survey of the bog and its immediate surroundings.
2. Determination of the thickness of the bog in its different parts.
3. Investigation of the physical state of the turf, its degree of sponginess, state of decomposition; and in connection with these the water-holding and water-conducting power of the soil.
4. Observation of the vegetation.
5. Determination of the state of the bog substratum in its different parts.

PRELIMINARY MEASURES FOR MANURING.

Drainage having been successfully carried out, the bog is not yet ready for cultivation. Baumann says that during the past one hundred years want and famine have given those living on bogs proof enough that the bog soil requires an *abundant supply* of plant food, such as lime, potash, phosphoric acid, and nitrogen—lime being the cheapest and nitrogen the dearest. Only such foods as are required should be supplied, and of these only enough for a good return. Stable manure, essentially a nitrogenous manure, should not be wasted. Without artificial manures an economical, reasonable cultivation of a bog is, it is stated, impossible.

It is only by their help that one can manure in the cheapest possible way, and so intermix the mineral foodstuffs the bog soils in question require.

Bog soils rich in lime, which are also as a rule rich in nitrogen, are to be distinguished from soils poor in lime, which are also usually poor in available nitrogen.

Meadow or green-land bogs are the ones rich in lime and nitrogen. Their vegetation has been often described. Sour grasses, bog-shrubs, and on drier parts true meadow and good fodder-plants.

The bogs poor in lime and nitrogen are the high bogs, on which the bog-moss Sphagnum, Eriophorum, Rhynchospora, Vaccinium sp., and also generally heather, appear as characteristic plants.

Thus the nature of the vegetation of the bog gives a starting point, ready to hand, for the manurial requirements as regards lime and nitrogen, but not as regards phosphoric acid and potash.

By traversing in all directions a bog, chart in hand, and noting on it the kind of vegetation, one can get an idea of the cost of the lime and nitrogenous manures required. As regards the potash and phosphoric acid requirements vegetation tells us nothing, more especially if any part has been under cultivation, and the primitive character of the vegetation has gone.

All bogs are poor in potash, and require accordingly a potash manure. By spreading on the bog soil rich in potash, one can, according to the character of the substratum, and by the mixing of the mineral soil, lessen considerably the manurial requirements. The meadow bog is richer in phosphoric acid than the high bog. Cases occur in which neither require it supplied as manure.

Chemical analysis must be undertaken, without which, Baumann says, no sensible agriculturist will attempt extensive bog cultivation. By chemical analysis the amount of food capital in the "root" or food-giving layer of an acre can be ascertained. Where the bog is large and varied in character many analyses would be required. Cases, too, are known in which the food matter shown by chemical analysis to be present is not available as such. Thus bogs are known very rich in nitrogen and in lime, yet improved by nitrogen or lime manuring respectively. In two bogs, equally rich in phosphoric acid, one may need a strong manuring with phosphate, the other none at all. Baumann states this is especially the case in bogs with previously burnt surface.

In such bogs the phosphoric acid is present in a more readily assimilable form, than in unburnt bogs.

Different quantities of lime, potash, phosphoric acid and nitrogen must be put into the bog, on which plants must be placed, and from the crops realised inference as to the manurial requirements drawn. On a large bog such experiments must be tried in several places. The botanical investigation and the chemical analysis are of the greatest help in indicating the further line of experiment by planting.

Thus in manuring the necessary preliminary measures to be considered are:—

1. Determination of the nature of the vegetation of the bog in its various parts, chart in hand.
2. Chemical analysis.
3. Volumetric weight determination of the surface layer (root-layer) based on the chemical analysis.
4. Manure experiments by planting.

PRELIMINARY MEASURES FOR THE FIRST WORKING UP OR TREATMENT OF THE SOIL.

There are bogs which need no working up. If a meadow-bog is flat, well decomposed, with many good food plants already on it, one only needs to drain it and distribute the necessary food materials. As a rule potash and phosphoric acid suffice, often potash alone. Such bogs are quite common in Bavaria, and their conversion into meadows is quite simple. Having only a slight turf layer they are mostly not of use for turf-cutting.

If the meadow bog contains a good deal of moss this is removed, after draining, with a good meadow harrow, adding to the cost of cultivation. Suitable grass seed and manure must also be distributed.

If the bog plants are only moss, sour grasses, equisetum, etc., in dense growth, it is then best to destroy the whole vegetation, either by ploughing up, levelling, harrowing, manuring and new seed, or by Saint Paul's method,by which Baumann states many thousand acres of bogland have been converted into fertile meadow.

The expense, so far, is relatively small, increasing as the vegetation partakes more and more of the character of a high bog. Many meadow bogs are quite thickly covered with small hillocks which often consist of high bog plants. It is absolutely necessary to remove these mounds with spade, and to level the surface, an operation which increases the cost considerably.

Other transition bogs are often occupied by alder, bird cherry tree, willow, pine, birches, or overgrown with vigorous tufts of rush, and bramble bushes. These must be dug or ploughed up and got rid of, and the soil broken up or loosened. If the ground is firm enough hand labour is replaced by horses, etc., and special instruments used.

At Bernau this costs about 2*s.* an acre. I am told that burning a bog surface has been carried out in some parts of Ireland, but that now attempts are often made to prevent this from being done. The objection raised is that the crops gathered immediately after the burning are good, but rapidly deteriorate. This is probably due to the non-supply of the food constituents removed. Burning is certainly largely practised at Bernau and on the Continent.

If the high bog is densely overgrown with heather this is best burnt living. In this way the hoeing, which must be done at least once, is very much facilitated. Badly decomposed high bogs need hoeing several times, so that their cost for the first working up and for rooting out (grubbing up) the wide spreading, interlacing roots is £4 to £5 an acre.

To estimate correctly the cost for the first working up of a bog one must know sufficiently—(1) its vegetation especially; (2) its physical state (firmness, degree of decomposition, occurrence of tree roots, and tree trunks in the surface layer).

PRELIMINARY MEASURES FOR "COVER" AND MIXED CULTIVATION.

When Rimpau discovered the "bog ridge cultivation," in which the bog is covered with a layer of sand 4 to 5 inches thick, and manured simply with potash and phosphoric acid, many believed the question of bog cultivation was solved. Rimpau raised at Drömling crops, the like of which had never been known in German bogs. Many naturally wished to share his good fortune. Bog cultivation on his lines was begun on a large scale but soon ended. In the hurry to grow rich many forgot that Rimpau had gained his success on a relatively flat, very well-decomposed bog, rich in nitrogen, with a good drainage, and with the aid of coarse sand. They also forgot that an excellent scientific manager, such as he, often gains success where others under similar conditions fail. Thus deep bogs, poor in nitrogen, badly decomposed, with unsatisfactory drainage, were covered *à la* Rimpau, and where coarse sand failed fine was used, or loam, clay, gravel, "meadow chalk," or anything they could lay hands on or get from the substratum. Everyone hoped the money laid out would bring in a handsome return. To many, indeed, the disillusion was not spared. On the deep bogs many had sad experience with subsidence before they could utilise the surface for cultivation.

High bogs poor in nitrogen are not at all adapted to covering with sand just as poor in nitrogen. Where sand was used it had later to be removed, as in west Germany, or mixed with the substratum, as in west Prussia. The Bremen Experimental Station proved, by systematic experiments, that Rimpau's "ridge" cultivation is not suited to raw high bogs. In some cases high bogs have been covered with sand with success, but then much more money was spent on manure to provide the necessary lime and nitrogen than in Rimpau's case. The bog, too, needed to be worked or built up beforehand, and to be in a well decomposed state.

Meadow bogs on which high bog plants grew in patches behaved similarly. Even meadow bogs, rich in lime and nitrogen, must be in a well decomposed state for success. Where this feature was overlooked the good crops of the first few years were followed by failures. The still soft bog became in its upper part so strongly pressed together that no air could get into it. No assimilable nitrogen, no nitric acid were provided, but instead frequently the offensive sulphuretted hydrogen, which acts as a powerful poison to plant growth. In addition there arose mostly a hard layer, which prevented the passage of air and water. The roots of plants could not make their way through it, and in consequence could not obtain their necessary nitrogenous food from the bog-soils. Plant-growth being arrested, complete failure of crops was the result.

The covering material itself often causes severe injury. Sometimes a high wind drives the whole sand, just after laying, into the ditches or the air. The sand must be renewed and the ditches cleared. Where heavy loam or clay has been used the sprouting of the seed, especially of rape seed, was poor. In dry weather the clay hardens and destroys the vegetation. In wet weather the clay becomes sticky and prevents air entering the bog. But most injurious of all are the plant poisons which make their appearance in the covering material—sulphuric acid, sulphate of iron and iron sulphide, through the choking up of the ditches or through the introduction of sub-surface soil into the surface of cultivation. In this way the vegetation was often completely and for years stopped.

Thus if the expensive "ridge" cultivation is not to fail one must first investigate:—

1. The depth of the bog in all its parts.
2. The vegetation on its whole surface.
3. The degree of decomposition in the upper bog layer.
4. The fertility of the bog.
5. The mineral soil in its substratum and in its neighbourhood in reference to the adaptability of this as a covering material.
6. The presence or not of plant poisons (iron sulphate, free sulphuric acid, sulphide of iron).

The annual rainfall must be taken into account—in some cases it is so high as to make the applicability of the covering process questionable.

The idea governing Rimpau's method is not that of cultivating the bog soil, but of building and working up a mineral soil laid on the bog soil to the depth of 4 to 6 inches. The water, lime, and nitrogen are to be supplied by the bog itself, the phosphoric acid and potash being supplied in the artificial manures. In this Rimpau broke new ground. The idea of improving poor soft bog land by mixing with it mineral soil—mixed cultivation—is very old, being, with the method of burning, the oldest. Mixed cultivation can be practised on many more bogs than can "ridge" cultivation. It also costs less, needing a layer of mineral soil 1–2 inches thick, not 4–6 inches, as in "ridge" cultivation. It has also its disadvantages. Thus it gives no sure protection against the frequent spring and autumn frosts of bog districts. "Ridge" cultivation is very valuable in this respect. Little is still known as to the applicability of mixed cultivation under different circumstances. The result appears to depend largely on the mineral soil employed. It has been observed that coarse sand gradually disappears (loses by sitting) when put on as a thin covering. In one case a sand covering 2½ inches thick did not mix at all with the bog, and nine years later was found 8 inches below the bog surface. Naturally the sand sinks far more quickly in a loose badly-decomposed bog than in a firm one. A layer of sand nearly an inch thick sank below the bog surface in about three years, and a layer 1½ inches thick in five years, leaving the meadow with more or less of its former appearance. Loam soil is more suitable; mixing better with the bog and the introduced food matter; especially it retains potash, which is otherwise easily washed out of bog soils.

Mixing is probably only remunerative with a very rich soil, which acts at the same time as a manure. Mixed cultivation is on this account most used in Sweden, where soils rich in potash and in phosphoric acid, are so often found in the substratum and in closest proximity to the bog. Experiments are needed to determine its applicability to Ireland.

At Bernau mixing of high bog soil with lime-containing loam soil has not proved remunerative so far, for potato-growing.

Meadow and high bog are to be sharply distinguished—they plainly respond differently to the same mixing matter. Shallow and deep, spongy, badly-decomposed, and firm, well-decomposed bogs will show a different relation to mixed cultivation and mixed soil, which Baumann emphasises can only be ascertained by systematic investigation.

When quite shallow bog soils are mixed with the underground sand the humus substance often quite disappears through oxidation, and a pure sand field results. In this case the cover method is preferable, as experiments show.

SUMMARY.

Thus the following works are necessary in the preliminary investigation for the cultivation of a bog. They may be divided into three groups, according to time and place:—

GROUP I.

1. Drainage relations must be made out, a survey carried out, and a general scheme of drainage prepared.

   (This is undertaken in Bavaria by the Technical Cultivation Office.)

2. The nature of the vegetation is to be determined, in order to make suitable arrangements for carrying out a detailed drainage for the working up of the soil (when necessary, cover and mixed cultivation also), and in order to get information as to the manurial requirements of the whole bog surface and its individual parts.
3. The depth of the bog must be ascertained in order to be able to measure the extent and kind of drying. It is only in this way one gets conclusive evidence as to the fuel supply of the bog.
4. The character of the soil of the substratum and of the bog surroundings must be learnt. This, externally observable, and determined by simple means, is necessary for the correct arrangement of the drainage and for the observation of the kinds of soil which are suitable for cover and for mixed cultivation and for manuring.

1–4 show conclusively whether the bog is or is not worth cultivation. They must be conducted in the bog district itself. During the inquiry one learns the local, commercial, and economic relations, and is in a position to say if the cultivation will or will not pay.

GROUP II.

This group is closely connected with Group I., and follows it immediately if the cultivation of the bog is to be successful.

With reference to the variety of vegetation, of the depth of the bog, and of the substratum, the Bog Cultivation Station takes samples of the soil of the bog, substratum, and bog surroundings, and determines:—

5. The specific gravity and the other physical characters.
6. The state of decomposition of the bog.
7. Its degree of richness in food; and, if necessary, the Government Station searches for
8. Plant poisons, in order to get further information for suitable drainage and manuring, for the applicability and carrying through of a ridge or a mixed cultivation.

5–8 must be carried out for the most part in a laboratory arranged for the purpose.

GROUP III.

This group leads back to the bog.

Building on our botanical information and the chemical analyses we now inquire:—

9. By manure experiments, how to get the best return from the drained and worked-up bog, 1–8 having served to prevent useless expenditure.

Taken together, the whole preliminary investigation should show how the unused wastes or badly-utilised bog-lands can be converted into fertile land with the least possible expenditure of money. With this object in view Baumann states the Governmental Cultivation Technical Office and the Bog Cultivation Station give their assistance free of cost to the carrying-out of these undertakings, to every Bavarian agriculturist or forester.

The bog-owner must himself pay for the preliminary inquiry in other German States, the minimum expense being £5. The complete investigation of a sample of soil at the Bremen bog-investigation station costs 30s. (Members of the Society for the furtherance of bog-cultivation are charged half-price.)

They supply him with a complete plan of cultivation, with practical guidance how best to drain, manure, work and build up the individual parts of the bog, or also how they should be utilised in turf-cutting.

By means of charts which, as Baumann says, show more clearly than words, he illustrates the kind of work carried out by the bog-cultivation station. These charts show well how thoroughly the work is done, and are generally very instructive. They embody the results of continuous investigations carried on since July, 1889, on the large bog near Bernau, on the south side of the Lake of Chiem at the foot of the Bavarian Alps. They provide a ground plan for modes of cultivation in all parts of the bog. With their help one can say how any one point stands in relation to the high land and waterflow, how deep the bog is, what sort of soil there is under the turf, whether we have to cultivate a high bog, a meadow bog, a transition bog, or a forest bog, and what mineral soils are to be found in the neighbourhood.

Colours indicate the character of the whole bog and of its different parts, showing the variety of vegetation on the bog.

Red violet colour indicates the high bog which occupies the largest extent of surface. It consists in the Bernau bog for the most part of a mixture of peat-moss (Sphagnum), heather and cotton-sedge; very often the white-beaked sedge replaces the cotton-sedge, and often also forms isolated patches. This most widely distributed high bog form is indicated only by colour, scarcely ever by special signs.

Other high bog forms, if of great extent, are indicated by dotted lines or special letters when of less extent.

If one finds only cotton-grass (the shoots of which are very persistent in the first working-up) covering a large surface it is indicated by the letter E. (Eriophoretum or cotton-grass bog.)

If one finds scarcely anything but heather, easily removed by fire, it is indicated by Cl. (Callunetum, heather bog).

If peat-moss mostly—in which case neither rye nor meadow cultivation is possible at first—Sph. (Sphagnetum) is used.

Similary V stands for Vaccinium uliginosum, the bog whortleberry, B for Birches.

Where two high bog plants form the prominent part of the vegetation the letters indicating them are put together. Thus
E. Sph. = cotton-grass + peat-moss bog (Eriophoreto-Sphagnetum).
Cl. Sph. = heather + peat-moss bog (Calluneto-Sphagnetum).
V. Cl. = whortleberry + heather bog (Vaccinieto-Callunetum).

That high bogs with different vegetation require different manures may be concluded from the preliminary chemical analysis. To get more detailed information numerous trials in the experimental fields are necessary.

The meadow bog is indicated by the blue-violet colour. The better parts, on which true sedges, "sour grasses," or sedges (species of Carex), and bog-shrubs, also different good meadow plants grow are indicated by C. (= Caricetum.)

Such stretches are made fertile by simple manuring without working up. Several acres have been in this way already converted by the Bernau Station. Where moss strongly predominates mostly Hypnums—*no Sphagnum*—one uses the sign Hp.

The meadow harrow must be used and grass seeds as well as manures harrowed in.

C. Hp. indicates an intermediate state where both groups are strongly represented.

A. indicates a rush or reed type of vegetation (= Arundinetum). The plants must be completely rooted out, thorough working up of the soil, sowing of seed, and manuring are necessary after draining.

C. Cl. (Cariceto-Callunetum) indicates heather-grown places in the meadow bog. In these places no cultivation is possible without thorough working up of the soil. A nitrogenous manure is probably profitable.

This is also the case on the true transition bogs, indicated by a reddish colour. They occur chiefly at the edge of the bog, contain all the typical high bog plants, and in addition quite often tufts of the moor-grass—Molinia cœrulea—as well as the Alpine cotton-grass (Eriophorum alpinum) and various other meadow-bog plants.

The brown colour indicates land now under cultivation, showing for the most part no sign of its original bog vegetation. The colours are traversed by fine straight lines, to indicate the depth of the bog.

≡ means the bog is not above 3 feet deep,
\\\ " " " " 3–9 "
||| " " " " 9–15 "
▩ " " " " 15–21 "

These signs give a general idea of the depth. The Station has made many borings in the uncultivated bog, so that it has exact knowledge of the depth of the bog at any point.

$\frac{160}{\text{cl2s.}}$ means the bog is 160 inches deep at this place, that the substratum cl. is clay 2 inches thick, and that below this is sand.

These soil charts of the Chiem Lake bogs have already been of much practical help to the Bog Cultivation Station and have simplified its labours very much. For of late years a greater number of landowners have determined to cultivate their bogs and have requested the aid of the Station.

These charts have their value for all time too. When once all the Chiem Lake bogs are cultivated then will it no longer be possible to say what was high bog, what was meadow bog, or where a forest stood.

Then may one ask why a cultivated plant gives a large return on one bog field but not on the immediately adjoining one; why the potato is watery and tasteless on one field, mealy and of good flavour on the adjoining one; why nothing grows here without stable manure and Chili saltpetre, while close by these manures are quite unnecessary.

Though we have not in Ireland the hot dry summers nor the cold winters of Bavaria, the bogs of the two countries are practically alike, they have the same flora and the peat shows the same stages of decomposition and progression downwards from grey to brown and black peat. "The peat-fibre" of the Irish bog is identical with that of Germany, Austria, Sweden, &c. A detailed account of the results of the investigation during the past ten years of the Bernau bog, promised by Dr. Baumann, this year (1899), should prove of the greatest interest and use. I hope to visit the bog station this year and to give an account of the results of the ten years' investigation. The object of this part of my Paper is to show the lines on which the Bavarian Government is working in attempting to help bog-owners to utilise their bogs, one-third as extensive as those of Ireland.

Part III.—METHODS OF HARVESTING PEAT.

I AM deeply indebted to my friend Professor Fisher and to Professor Schlich for permission to include in this Paper the following account of the methods of harvesting peat, drainage of bogs, drying of peat, &c., from vol. v. of their "Manual on Forestry," a work which should be in the hands of every landowner:—

Before undertaking to work a peat-bog, a full estimate should be prepared of its quality and its probable volume, in order to determine whether the outlay of capital expended in removing the peat will be covered by its value and that of the cleared land.

1. *Quantity of Peat.*

The following data are required to estimate the quantity of peat in a bog: the area, depth, amount of shrinkage of the dried peat and the loss of peat during its extraction.

(a) The area of a bog should be ascertained by surveying it.

(b) The depth may vary considerably at different points of a bog, which is not unfrequently intersected with one or more layers of sand, loam, or trunks of trees. In order to become acquainted with the nature of the bog, it should be divided into a rectangular network, the points of intersection of which may be about 27 yards (25 metres) apart, and are marked by numbered stakes. Three methods can then be followed; either strong poles are driven down at each numbered point to the bottom of the bog, pits 2–3 yards broad are dug or a peat-borer is used.

Driving poles into bogs may lead to false inferences, if beds of marl or trunks and stumps of trees, &c. are imbedded and prevent the poles from reaching the bottom of the bog. Digging pits is often impracticable owing to the accumulation of water and always involves much labour and expense, but this method affords the best possible insight into the nature of the bog and must be employed to ascertain the quality of the peat. It is best to use the peat-borer, as this generally gives satisfactory results and saves much labour. Since, however, few bogs are level at the surface and their bed is often undulating and irregular, levels should be taken all over the surface of a bog, the levels of the bottom and top of each point of intersection being fixed with reference to a horizontal plane through the highest point in the bog. This levelling will show what is the contour of the bog, a knowledge of which is requisite before its drainage can be undertaken.

(c) With the help of the above factors, the contents of the peat-bog may be estimated in cubic feet. In order, however, to estimate how much marketable peat there may be, a deduction must be made for **shrinkage.** For as soon as a bog has been drained, it settles down and shrinks the more, the more thorough the drainage. The amount of shrinkage must be calculated by experiment.

Thus pieces of peat of the ordinary dimensions are cut from several trenches and thoroughly dried, their volumes being calculated before and after drying and the difference between them being the amount of shrinkage. This is generally from 30 to 50 per cent. of the volume of freshly cut peat.

(d) Finally the **loss of peat during extraction** must be estimated: this varies in quantity according to the skill of the workmen, the quantity of stumps or stems of imbedded trees and the cohesiveness of the peat; the better kinds of peat are much more brittle than inferior fibrous peat.

During frosty weather in winter, the walls of the open peat-trenches frequently crumble considerably; besides this waste, ridges of peat remaining between the trenches cannot frequently be utilized. Thus a loss of peat occurs, often 25 or 50 per cent. of its whole volume. If, however, this otherwise wasted material can be moulded into turves, no loss need accrue.

2. *Quality.*

The quality of the peat is ascertained in the above-mentioned manner, both as regards its efficiency as fuel, and the possibility of thoroughly draining the bog.

It has already been remarked that the quality of the peat varies in the different strata of the bog, the best peat being, as a rule, at the base of the bog and the inferior kind at its surface. In order to ascertain the nature of the peat throughout the bog, several experimental trenches are dug : the refuse is set aside and the fibrous peat stacked apart from the black peat, the relative proportion of each kind being calculated; the muddy peat at the base is then dredged out and each kind analysed.

As the value of peat depends on the quantity of combustible matter in it, which is greater the less water or ash the peat contains, the analysis is chiefly directed to ascertaining the quantity of water and ashes in the peat. The contents of the peat in bituminous substance and uncombined carbon, which is always a test of its value, may be found by extracting them with ether.

The value of a peat-bog also depends on the possibility of draining it. If a bog can be thoroughly drained within a year from the commencement of working it, the admission of oxygen from the air will more or less quickly convert the insufficiently decomposed and less valuable peat into rich black peat which is the most valuable kind. Well drained peat also crumbles far less than when the bog is undrained.

It is evident that if a bog is to be properly utilized, it should be worked in accordance with a fixed plan prepared beforehand ; this plan specifies how much peat should be dug yearly, where the digging is to be commenced, in what direction it is to be continued, according to what principles it is to be drained, and the best lines for transport. Wherever there is an intention of utilizing the peat and then converting the bog into a forest or meadows, so much of it will be dug each year in accordance with the purpose in view, to which the utilization of the peat is merely subsidiary.

If, however, it is intended to have a permanent supply of peat, only so much should be dug yearly as the bog produces in a year.

Fresh peat is produced regularly in all bogs where the conditions remain unaltered. Thus some bogs produce annually layers of peat 5 or 6 inches thick, or even thicker; others a mere film of new peat, and others none at all.

The first condition for a renewal of the peat is a drainage system by means of which the parts of the bog from which the

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peat has been dug can be properly irrigated. If these portions can be kept submerged continually, but not too deeply (about 2 to 4 inches), whilst here and there ridges and mounds remain above water-level, the water containing humus and the base of the bog not being completely freed from peat, a continual production of peat may be confidently anticipated. In order to secure these conditions, the useless upper layers of peat and other refuse are thrown on the cleared areas and trenches, care being taken to keep these latter inundated.

The mode of reproduction of a bog cannot be explained in a general manner, but only observed on individual bogs, whilst any change in the drainage of the surrounding land may greatly affect matters in this respect. As, therefore, a long period is required for such observations, during which changes in the water-supply may occur and the rate of production of peat vary in different parts of the bog, it is rare that working plans for a bog take into consideration its reproduction. It is, therefore, considered sufficient to prepare a plan for from 50 to 100 years, according to the extent of the bog, the demand for the peat and amount of labour available; a fixed quantity of peat is thus supplied annually, whilst the cutting proceeds in a proper direction. In the latter respect, it is customary to commence operations at the highest part of the bog, if it is intended that the peat shall be reproduced, and thence to proceed gradually to its lower parts.

DRAINAGE OF BOGS.

1. *General Account.*

Peat can be utilized only after a bog has been partially drained. It is chiefly small bogs resting on a sloping bed which can be worked without draining. Drainage is always necessary in the case of large bogs. The object is not to drain the entire bog, but only that portion which it is intended to work immediately and to such an extent that the peat may be readily dug and dried. The remainder of the bog should be kept thoroughly wet in all cases where the reproduction of the peat is intended, and also to protect the peat from being frozen[1]; this is also frequently useful when the land already freed from peat is to be cultivated.

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[1] [Cranberry bogs in N. America are regularly inundated when threatened by frost, in order to protect the plants.—TR.]

All parts of the bog which are not being utilized should be kept thoroughly wet during winter, or the peat will be seriously injured by frost. When wet or damp peat is frozen it does not become compact again on being dried, but crumbles. If the cleared bog is to be planted with trees or converted into meadow-land, it is not advisable to drain the bog completely, but only to remove the superfluous water.

The method of draining a bog depends essentially on its situation and nature; one or other of the following methods being adopted:—leading water away in drains, cutting off the water-supply, collecting the water in drains or tanks, or causing the water to sink through an impermeable subsoil.

2. *Ordinary Drains.*

The usual method of draining is to lead the water from the bog in ordinary open drains. It is then essential that some land near the bog is on a lower level than its bed; this generally occurs. The levels taken off the bog and the immediately surrounding country show the difference of altitude between the lowest point of the bed of the bog and that of the external land, and the gradient of the line joining these two points. This is the line of greatest fall, and should be the direction of the principal drain.

It should be noted that a steep gradient is desirable only outside the bog; within the bog the gradient of the drains should be less the more water the bog contains. Digging the principal drain is commenced at its lowest point outside the bog; it often suffices to continue this drain up to the bog, but, as a rule, it should be conducted to the lowest point within the bog. In case a brook runs through the bog it may often be used as the principal drain after some cuts have been made in it to improve the flow of water. If the bed of the bog slopes down towards a neighbouring river or brook, this slope affords the best gradient for the drainage. If, however, the bog lies in a depression surrounded by higher land, it is a question of expense whether to cut through the latter or construct a tunnel to serve as a drain.

The dimensions of the main drain depend on the gradient and the quantity of water to be removed. It is not generally necessary to drain down to the bed of the bog. Too broad or deep drains often injuriously dry up the bog and are extremely costly both in construction and maintenance. Where the drain leaves the bog a simple sluice-gate should be constructed in order to retain sufficient water in the bog during winter. In the case of small bogs and drains, instead of a sluice-gate the inlet into the main drain is blocked in autumn with peat.

If there is much change of gradient in the bed of a large bog, several draining trenches are cut through the latter. It is often advisable to cut these drains from a certain point in the bog, and then lead them outwards in diverging directions, which generally cross one another at right angles.

Whilst the main drain is generally completed once for all, the subsidiary drains are dug gradually during the progress of removal of the peat. They are generally at right angles to the main drains and are intended to drain only that portion of the bog which is being worked. They are naturally smaller than the main drain.

In the extensive bogs of Holland, Friesland and Bremen the main drains serve not only for drainage, but also for the purpose of communication by barges and conveyance of the peat; they are frequently 26 to 32 feet broad.

3. *Drains for Cutting off the Water from Bogs.*

There are frequently small watercourses which run into a bog, or water runs down a slope into it. If then trenches can be dug so as to cut off the water-supply from the bog, they are very serviceable as an aid to ordinary drains, but will not alone suffice to drain the bog.

4. *Collecting Drains and Tanks.*

A large number of bogs are supplied with water by infiltration from neighbouring watercourses. If then the bog lies above the level of the water it is possible to drain it in the ordinary manner; this cannot be done if it is on about the same level as the water. More extensive works are then usually required (which are too costly where peat-digging is concerned) in order to exclude inundations from the bog, or remove the water from collecting drains by means of pumps and hydraulic engines. Only when the inlet of water is inconsiderable can water which collects in the drains during the night be removed by manual labour. The construction of a sufficiently large tank near the bog to receive the water can be only exceptionally undertaken.

5. *Piercing an Impermeable Pan.*

If a bog should rest on a thin bed of loam or clay, below which is an impermeable stratum, or pan, of gravel or sand, the simplest method of draining it is often to bore or break through the pan and thus allow the water to sink below it. If, however, the shaft through the pan is made at the deepest part of the bog its drainage may be too thorough, and thus injuriously affect the peat.

HARVESTING THE PEAT.

The removal of the peat may be effected in various ways. A distinction is thus made between peat dug by manual labour (*Stichtorf*), peat which is moulded into shape (*Modeltorf*) and peat removed and prepared by machinery (*Maschinentorf*).

1. *Peat Dug by Manual Labour.*

Only fairly compact peat can be dug by means of spades and the pieces, termed **turves**, are then dried in the sun and by exposure to the air. The different operations in the case are the preliminary works, and digging, drying and storing the peat.

(a) **Preliminary Works.**

(i) *Subsidiary Drainage.*

After the main drain and the most important side-drains have been dug, further subsidiary drainage must be done annually. This is effected by making a trench a little way from where the peat is to be dug, parallel to the line of digging and perpendicular to the main drain, so that either the whole or a portion of the area to be dug in a year may thus be drained. As soon as the season's digging is over, the junction of each of these drains with the main drain is closed in order to keep the bog sufficiently moïst.

(ii) *Laying out the Line for Digging.*

The area where the peat is to be extracted in accordance with the plan of operations, should then be measured and marked out with shallow trenches, so that the workmen may know where to dig.

As a rule, the peat should be dug in successive years from immediately adjoining areas and no wall of peat left standing between them, which is usually a sign of bad management though sometimes necessary where there is a superfluity of water. Each year's area should consist of a long, narrow strip, parallel lengthwise to the subsidiary drain. Such a shape allows a number of men to work simultaneously, renders drainage by means of a single trench possible and allows sufficient room for drying the turves, which are generally piled on a strip of land previously marked out and adjoining the digging trench. All vegetation should be cleared from this strip, so that the turves may be easily piled and thoroughly exposed to the air.

(iii) *Laying out Roads.*

The turves must either be dried on land adjoining the bog, or on the bog itself and then removed. In either case roads are necessary, which should be made on the driest part of the bog, be as permanent as possible and cross the drains only when this is unavoidable, in order to avoid the expense of bridges. Roads should be made of fascines and sifted gravel whenever they traverse wet ground. If the turves are removed in wheelbarrows from the digging-trench to the drying-ground, only a narrow pathway is required.

(iv) *Removal of Wood.*

On many bogs a certain number of trees are growing (mountain or Scotch pine, alder, birch, &c.), and their usually spreading roots often interfere considerably with the digging. These trees should be felled a year before the turves are dug, and their main roots extracted.

(v) *Management of Labour.*

Labourers employed in digging turves should be divided into parties, as in the case of forest work. According to the methods employed for digging and drying the turves, three, four or even more workmen form a party. The digging-ground is then subdivided into as many sections as there are parties of labourers, provided a certain length is not exceeded, in North Germany usually 2 or 3 yards (metres), and in South Germany 4 or more yards, per man. These measured lengths are staked out, numbered and distributed by lot among the parties.

(b) Digging the Turves.

(i) *Season.*

It has already been stated that peat is damaged by frost, and this is the case both with uncut peat and turves. One or two degrees below freezing point is sufficient to do the damage. Frozen turves do not shrink after thawing, but dry the same size as when frozen; they are therefore very porous, form inferior fuel and crumble easily. Digging turves should not therefore commence until there is no longer danger from late frosts.

Although it may appear profitable to dig turves during dry spring weather, yet experience proves that a single late frost will damage the turves, so as to nullify all the advantage of early work. In countries therefore with a mild climate, digging turves should be commenced about the beginning of May, in mountainous and northern countries, from the middle to the end of May. The work should stop sufficiently early to allow the turves to dry thoroughly. This also depends on the local climate and especially on the humidity of the air. Digging turves generally terminates about the end of August, if the turves are dried out of doors. When they are dried artificially, the work may continue for a longer period.

(ii) *Size of the Turves.*

The size of the turves depends on the compactness of the peat and the time required for drying them. The lighter and looser the peat, the better it holds together during digging and drying, the more quickly can the turves be dried and the larger they may be. In the case of black, amorphous peat, the turves are smaller than with brown peat.

(iii) *Implements.*

All the implements used for digging turves are modifications of the garden spade.

The Frisian spade is used for digging vertically; the spades used for digging horizontally have short handles, but very sharp and perfectly flat blades. A two-bladed spade with one blade at right angles to the other, in order to loosen the turves on both sides at once, is used in the Rhine Provinces. By means of a spade used for vertical digging in Upper Bavaria, the turves are cut on all sides. A spade is used in North East Germany to remove the useless superficial turf and sods of earth. A three-pronged fork resembling an ordinary dung-fork is generally used for putting the turves into barrows or carts for transport.

(iv) *Digging Turves.*

There are two methods of digging turves, termed respectively the **horizontal** and **vertical** methods. The former method is almost universally employed in North Germany and is common in the Rhenish Provinces, and South Germany. The vertical method is practised in some Upper Bavarian bogs and in the Baltic Provinces. In the **horizontal method**, a workman beginning at the top edge of the wall of peat, cuts the vertical lines of a turf with the Frisian spade, whilst another workman standing in the trench, cuts the turf horizontally and sideways from the bank of peat.

In the **vertical method**, the workman standing on the top of the bank of peat cuts each turf free by one vertical or slightly oblique stroke of the spade and tears it off from below, raising it with the same spade on to the bank of turf. As by this method the turf is broken off above and below, it has not a regular cubical shape; control is thus rendered more difficult, while there is more refuse from crumbling than in the horizontal method. At the same time the vertical method is less laborious and cheaper than the other. According to the skill of the workmen and the difficulty of cutting the peat, with horizontal cutting, 3000 to 5000 turves may be cut in a day, and with vertical cutting under favourable circumstances 6000 to 7000 turves. The vertical method is obligatory whenever the bog is insufficiently drained.

Before beginning to cut the turves the topmost layer of soil must be dug up in sods, as long or double the length of the turves, by means of the Frisian spade; these sods should be removed from the bog in wheel barrows or carts.

The methods of cutting turves also vary, in the case of either horizontal or vertical cutting, according as the peat-bank is cut in **continuous** or **alternate strips.**

When the turves are cut in **continuous strips**, a commencement is made on the longer side of the area marked out for the year's cutting and strip after strip of peat is removed until the work has been completed. In this case, the work going on continuously down to the bed of the bog, there is either a vertical bank of peat left, or this bank may be in steps and the work proceed by cutting first from the top-most step, then from the second step, and so on. In this case the turves are removed from the bog as soon as they are cut, so as to leave room for the workmen to dig.

When the turves are cut in **alternate strips**, they are stacked close to the cut, like a wall, the strip on which they stand being left uncut and a new strip commenced immediately beyond it. In this case also, a deep bog cannot be at once cut to its full depth, but the work must be done in two operations. As soon as the stacked turves are dry and have been removed, the work of cutting the intermediate strips is undertaken.

Cutting in alternate strips is cheaper than in continuous strips, as a separate labour force is not then required for removing the turves to the drying ground ; this method is also especially applicable when the bog is wet or insufficiently drained, also when it is superficial and can be cut in one operation. It has, however, the disadvantage that the turves are all from the same level and is not advisable for deep bogs.

(v) *Obstacles to Cutting.*

Besides the water, which may prevent the cutting going down to the bed of the bog, various foreign bodies are imbedded in the peat forming so many obstacles to the digging; among these are stones, beds of sand or marl, roots and stems of trees, &c. Stones are frequently found in morasses and fens, besides interrupting the cutting they injure the implements. Layers of sand and marl often cause temporary flooding and must be cut through to let the water pass. Imbedded roots and stumps of trees are often serious obstacles in high peat-bogs. When these are stumps of resinous conifers, they are usually quite undecomposed[1] and must be completely removed. Large quantities of peat are sometimes wasted owing to the presence of stumps and long side-roots. Superficial roots of birch, alders, &c., in the upper layers of a bog are not so prejudicial, as they are generally rotten and can be severed with a spade.

Machines have recently been constructed, to replace manual labour in cutting turves, one invented by Browowsky[2] is used in North Germany, and cuts turves 3 to 6 yards long and 1¾ by 2¼ feet in section, even from undrained bogs. These large turves are then cut into smaller sizes by manual labour.

(c) **Drying the Turves.**

As much care should be taken in drying as in digging turves, for their value as fuel depends greatly on the thoroughness with which they are dried. The air dries the interior of turves better than solar heat, which quickly hardens their surface but leaves them still wet internally. Turves may be dried either out of doors, or under cover.

(i) *Drying Turves out of doors.*

The drying-ground is either on the bog itself, or on an adjoining plot when the latter is too wet; as already stated it should be prepared before digging the peat. The turves are stacked in various ways, according to the space available for drying them, their comparative wetness and rate of drying, and the available labour-force; in order to dry them properly, however, they should always be turned over several times.

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[1] In the Landstuhl bog, near Kaiserslautern, there are three layers of Scotch pine-stumps separated by peat, which yield annually 28,000 cubic feet of stump wood. They are converted into tar.

[2] Hausding, *Indust. Torfgewinnung*, p. 25.

As soon as they are cut, the turves are usually removed by the workmen, either in wheelbarrows, or by the men forming a chain and passing them from hand to hand. They are then placed singly and on their edge, like bricks, at short intervals, or piled in little stacks of five turves each; or round a stake, up to a height of 3 to 4½ feet, a method usual in Swabia and around Lake Constance; or, as in some parts of Austria, stakes are driven into the ground with 9 or 10 transverse sticks attached crosswise to their ends, on which the turves are impaled. After a preliminary drying, the turves are turned over once or several times, the lowest ones being brought to the top of the stack, and vice versâ.

As already explained, when space is limited the turves are first dried on the top of the bank of peat, which is then cut in alternate strips. It is evident that the turves when stacked for drying do not dry so quickly or thoroughly as when placed singly on the ground. The lower turves must therefore be further dried on the drying-ground and for this purpose may be placed in circular rings of 5 or 6 turves on the ground, over which 4, 6, or 8 rings are placed, the space between two turves in a lower ring being covered by a turf in the ring above it.

When the turves are thoroughly dried—for which 4, 6, or 10 weeks are required, according to the weather, mode of drying and quality of the peat—if they are to be at once sold and removed, they are piled in the usual rectangular or conical sale-stacks, each containing 1000 turves, or else in stacks similar to those used for fire-wood.

(ii) *Drying under Cover.*

Sheds for drying turves are similar to those used for bricks, being very long and narrow and formed of laths which are covered with a light roof and in which the turves are stacked one above the other. These sheds offer the great advantage that the drying process is independent of the weather, but they are too expensive for general use.

Drying is, however, much more rapidly and thoroughly conducted in sheds, than in the open air, observations at Waidmoos having shown that in four weeks turves thus dried lost about 20 per cent. more moisture than in the open.

(iii) *Shrinkage.*

From 70 to 90 per cent. of the weight of freshly cut turves is water; most of this is lost in drying, but air-dried turves still contain 26 to 30 per cent. of water. In passing to the air-dried condition, turves shrink considerably, the more so the better their quality.

Some peats lose 70 to 75 per cent. of their volume by shrinkage, so that a volume of 100 cubic feet of wet peat becomes only 25 to 30 cubic feet when dried. Fibrous peat on the other hand does not shrink much, but loses much more in weight than good peat, weighing frequently only one-fifth, or even less, of its weight when freshly cut.

(d) **Storage of Turves.**

The turves cannot always be at once sold and removed, but must sometimes be stored through the winter. This is done either in the open, or in covered stacks.

The cheapest method is to pile the turves in either conical or prismatic stacks sloping at the top. Turves which are not thoroughly dried may, however, be easily spoiled in this way. The stacks should be erected in a dry and somewhat elevated place and carefully piled.

The turves are much better protected from damage when the stacks are thatched. Straw, reeds, spruce-branches or bracken will serve the purpose; better still, a light plank roof supported by four posts may be erected with a slope towards the rainy quarter, or the turves may be placed as follows—in the centre of a cleared space a strong stake is driven vertically into the ground, and billets placed radiating in a circle from the stake (as in the base of an Alpine charcoal-kiln) and covered with planks; the turves are then piled on this floor in a truncated cone thatched with straw. From these thatched stacks the turves can be taken during winter according to requirements, this can be done from uncovered stacks only at the risk of spoiling them.

Whenever the value of turves is sufficiently high, it is best to store them in sheds, which should have their greatest length perpendicular to the direction of the prevalent wind, and be lightly built of planks or laths, so that the wind may blow through them, the rain being kept out by a roof.

2. *Moulded Peat.*

Some peat is not sufficiently compact to be cut into turves, but must be moulded. This is the case with bogs containing much imbedded wood, or so dry that the peat crumbles into dust, or excessively wet so that the peat must be dredged; also where the peat is only ordinarily moist, but cannot be cut into turves owing to the presence of numerous undecomposed roots. In ordinary peat-bogs, however, where turves are cut, there is always a large percentage of waste peat resulting from the digging, drying, or transport of the turves, which can only be utilized by moulding it. This waste frequently amounts to a fifth or a quarter of the annual yield of peat.

The different works in question are—**preparing the peat, and moulding and drying the turves.**

(a) Preparing the Peat.

Peat which is to be moulded should form a homogeneous mass, containing a suitable amount of water, and capable of being kneaded. If the peat is naturally powdery and dry, it should be mixed with water in a pit or a wooden bin with holes in its base; if it is muddy peat with a superfluity of water, it must be dredged out of the bog with a hollow shovel or in a purse-net, and poured into the bin or on straw laid on the ground, so that the superfluous water may drain away. In whatever way it is collected, the mixed peat and water must now be thoroughly kneaded and worked together until they form a fairly homogeneous mass. This is generally done by men trampling on it with bare feet or with flat clogs, less frequently with the help of hoe or spade.

When the peat is of the ordinary consistency and moisture, the workmen place planks in the trench in front of the bank of peat, and cut the peat away from the bank with a sharp cutting mattock, letting it fall on the planks, and watering it sufficiently by means of wooden buckets. In Holland and several places in North Germany (especially Hanover), the peat-pulp is left alone to dry for a few days, and then again kneaded. In South Germany, it is moulded while still very wet, the second operation being omitted.

(b) Moulding the Turves.

The turves should be moulded at a place close to where the peat has been dried. If this is at any great distance from the bank of peat, the peat-pulp is removed in baskets or bins which are placed on wheelbarrows; it is then thrown on to straw or planks, and is either cut or moulded into shape, the moulds containing several compartments or being similar to those used for brickmaking.

Peat-pulp is cut into shape in Holland, Friesland or Hanover, being spread out in layers, often half an acre in extent, and beaten flat with flat wooden shoes, planks or shovels. The pulp is allowed to lie for several days, and when sufficiently dry and consolidated is cut with sabre-like blades or sharp spades in parallel strips as broad as the turves are long. After a few more days' exposure, these strips are cut into turves.

When on account of its watery condition, the peat-pulp is collected in perforated bins, in which it is worked up, it is moulded into turves by means of wooden frames without bases; these are placed on the ground or on a bench, and the pulp poured into them. Its surface is levelled by means of a board which is also pressed down on the pulp in the frame to expel the water.

Moulds of several compartments are composed of rectangular wooden frames open above and below, and divided into 16, 28, 36 or more compartments, each the size of a turf. A mould is then placed on a bench, or on a substratum of straw, reeds, &c.; the peat-pulp is poured into its compartments by a shovel, pressed down, and the mould is then removed. In order that the turves may not stick to the sides of the compartments, they are lined with tin, or their bases are somewhat wider than their tops.

Simple moulds resembling those used in brick-making are used by a workman standing before a bench, often made of cast-iron, on which the mould is placed. The mould is of wood, open at top and base, its interior the size of a turf and generally lined with tin. The workman from a heap of a peat-pulp on his bench, takes sufficient with both hands to fill the mould, strikes off the superfluous peat with a board, the size of the base of the mould;

he then places the board over the mould, turns the latter over, raises it and leaves the turf resting on the board. A second workman takes the board and turf to the drying-ground, and brings back the board. In the meantime the former workman continues to make turves with the mould and other boards.

Experience shows that a simple mould is at least as expeditious as a multiple one, a man, with a boy to remove the turves, preparing 1000 to 1500 turves in a day. As moreover the peat-pulp passes again through the workman's hand, and all foreign matter can thus be removed, the turves in that case are more uniform and free from extraneous matter, and as the peat is not poured but pressed into the mould, the turves are denser than in the former method.

(c) **Drying Moulded Turves.**

Moulded turves must be more gradually and carefully dried than those which are cut directly from the bog. When peat-pulp is cut, the turves are left to dry for a few days, and then turned on to their narrow sides; they are then generally piled in superposed rings. They must be turned again once or twice, according to the state of the weather and are stacked when completely dried. Moulded turves generally dry more quickly than cut turves, especially when they are moulded like bricks and dried like ordinary turves.

When the peat is very watery and moulds of several compartments used, it is better, after the preliminary drying on the ground (which is not required for brick-moulded turves) to place the turves under cover, as they cannot withstand prolonged rain. Turves made in multiple moulds may be entirely destroyed by rain, so that this method can only be adopted in fine weather.

(d) **Quality.**

Moulded turves generally afford a better fuel than cut turves, in ratios of 5 : 3 or 5 : 4. This is due to their greater homogeneity, the removal of extraneous matter, greater density and the use of amorphous peat, which is often wasted when the turves are cut from the bog.

The bog was superficially ploughed by a steam-plough. All the refuse peat was finely subdivided, dried and conveyed to the factory. It was then sifted and thoroughly dried in a specially designed hot-air chamber, which it left with only 10 per cent. of moisture, and was then converted into turves by a powerful press.

This product, however, did not answer the purpose intended, as it fell into dust while burning, and was scarcely superior, as fuel, to the best ordinary turves.

(c) **Wet pressure.**

Owing to the obvious advantage resulting from pressing the wet peat, and thus increasing its density, and at the same time its compactness, more attempts have been made in this direction than in any other. No attempt, however, to press raw peat has succeeded, partly on account of the fibrous nature of the peat, which caused it to swell again after the pressure had been removed, and partly because the valuable humus-carbon escaped with the water, and thus the product deteriorated as a combustible. Other kinds of pressed turves were too dense externally, and their interior either did not burn well or else retained too much moisture.

(d) **Destruction of the structure of the peat, with or without pressure.**

It is now everywhere recognized that the structure of the peat must be destroyed before the turves are formed, and that only a moderate pressure, if any at all, is advisable. The apparatus of Schlickeysen and Geysser, Gratjahn and Pilau, Thecke and Sander, Weber and Mattei, are those best known for this method.

(i.) *Method of Schlickeysen*[1] *and Geysser.*

A vertical axle is movable by steam-power in a vertical, hollow, cast-iron vessel, with a funnel-shaped top. On the axle are six sharp horizontal knives, fitted to it like the thread of a screw, while six corresponding knives are on the walls of the vessel. There is also a moveable base, which is attached to the axle and rests on the real base of the vessel, and immediately above it are two holes on opposite sides of the vessel through which the prepared peat passes. The peat placed in the vessel while the axle is in motion is cut into shreds by the knives, which also cut through all pieces of roots; it is at the same time pressed slightly downwards by their screw-like action, and finally passes out through the holes in a round rope-like mass of stiff paste. This runs out continually on to a bench, and is cut into pieces and dried.

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[1] Leo, Die Kompression des Torfes.

Although no water is added to that originally in the peat, the latter is quite plastic. The fresh turves are only moderately dense, though covered superficially with a smooth gelatinous coating they are yet capable of being easily and thoroughly dried There is no loss of humus-carbon, which during the macerating process becomes attached to the walls of the vessel and issues from it as a glazed coating to the turf. In 12 hours, 15,000 turves, each a foot long can be cut from each side of the vessel, and in favourable weather they dry rapidly with a considerable shrinkage. This turf can be used not only as ordinary fuel, but also in the manufacture of glass and porcelain, it must then be dried in kilns. Geysser has invented hand-machines of a similar description to the above, and capable of turning out 2500 to 3000 turves in a day. These hand-machines have the advantage over that of Schlickeysen, of saving the transport of the wet peat, besides saving fuel, and can be worked on the bog; at the same time they are not applicable in the case of very fibrous peat, or where there are many roots. Geysser dried the peat in an excellent manner in portable drying sheds, consisting of frames like hurdles placed one above the other, and covered with a roof.

(ii.) *Method of Gratjahn-Pilau.*

Some progress has certainly been made in the quality of machine-made turf. Hausding[1] states that air-dried machine-turf, with at most 10 per cent. of ash has $\frac{2}{3}$rds the heating power of superior coal, so that one cwt. of machine-turf is equivalent to $\frac{1}{2} = \frac{2}{3}$ cwt. of coal, whilst ordinary turves are equivalent to only $\frac{1}{3} = \frac{1}{3}$ cwt. of coal.

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[1] "Industrielle Torfgewinnung, Berlin, 1887," by Seydel.

It may here be noted that several attempts have also been made to carbonise peat and produce peat-charcoal in order to increase its market value as a fuel.

II.

LECTURE ON FORESTRY GIVEN BEFORE THE ROYAL DUBLIN SOCIETY, MARCH 3, 1899, BY W. R. FISHER, B.A.,

Assistant Professor of Forestry, Royal Indian Engineering College.

THE chief difficulty in a lecture on Forestry is to bring before the audience, within a limited time, some of the more important points in a vast subject. As an illustration of this, I may state that the Manual of Forestry, written by Dr. Schlich and myself, contains 2400 pages, and although it was termed by one of our reviewers an "Encyclopædia of Forestry," yet it is by no means an exhaustive work on the subject.

IMPORTANCE OF SCIENTIFIC TRAINING, AS WELL AS PRACTICAL EXPERIENCE, IN FORESTRY.

The view of Forestry as an industrial art, requiring scientific training as well as practical experience, is not, however, that generally adopted by the people of the United Kingdom, many of whom imagine that woodlands can be managed by anyone endowed with a little common sense, and without any special training, and that woods are chiefly to be regarded as picturesque additions to the country side, or as covers for game, whilst their economic aspect, as sources of a remunerative timber supply, is seldom considered seriously. I have visited the Black Country near Wolverhampton, and contrasted that dreary expanse with the finely-wooded country immediately adjoining it, beyond Dudley, and in 1894, I advocated the planting with trees of this waste area of old pit refuse heaps, which already produces inferior herbage and is grazed upon by grimy sheep; I am not, therefore, likely to fail in acknowledging that woodlands beautify a country, but to-day I intend to deal chiefly with the economic side of forestry. Ireland may have lost in wealth by not having any Black Country, but is renowned for verdant beauty, owing to her ample rainfall. More woodlands are, however, required to prevent denudation of her hillsides and to maintain a steady supply of water in her streams, though no fear need be entertained as to the climate being thus rendered too moist. I hear that many of the plantations made in Ulster in the early part of this century have disappeared, and much more woodland might advantageously be grown as shelter belts for cattle, as well as for the production of timber for home use in fencing, building, and for other purposes, or for export as pit-props, wood-pulp, railway sleepers, telegraph posts, and other miscellaneous wares.

The fact that many distinguished men, chiefly in France and Germany, have devoted their lives to Forestry, and have obtained honours from the Governments of those countries for their labours, whilst there are numerous Schools of Forestry in Europe, may be adduced to correct the misconception that foresters do not require training. I may also point to the successful management of the forests of India, where, since 1866, specially trained foresters have been employed in constantly increasing numbers, and to the forest schools of Cooper's Hill in England, and of Dehra Dun and of Poona in India, which now train all new Controlling and Executive members of the Indian Forest Department, not only for British territory in India, but also to a large extent for the native states of Kashmir, Mysore, Hyderabad, and many others.

Last year, an American School of Forestry was founded at Cornell University. Two German-trained foresters teach forestry there, one of whom, Mr. Fernow, has been for a long time at the head of the Forestry Branch of the Agricultural Department in the United States. A friend of mine, Mr. Gifford Pinchot, has just succeeded Mr. Fernow as chief of the Forestry Branch in the United States. He is a most energetic man, who has studied forestry for several years in France, Switzerland, and Germany, and has learned much of its application to newer countries from Sir Dietrich Brandis, the founder of Indian scientific forestry, and from Dr. Schlich, who was formerly at the head of the Indian Forest Department, and is now the principal Professor of Forestry at Cooper's Hill. Considering that Mr. Pinchot is a wealthy man, the energy he has shown in acquiring a good knowledge of forestry is most creditable to him, and bodes well for the success of his future control of forest matters in the United States.

One of his first measures has been to issue a circular, offering through State agency, to draw up management schemes for the forest lands of private owners in the United States, for which a small charge is made to cover expenses. Within a few months applications have been received to deal with 1,500,000 acres of private woodland.

The Crown Forests in England have hitherto been entrusted to men generally selected otherwise than for their knowledge of forestry. Now although the race is so good, that Britons, however inexpert, generally rise to the level of their responsibilities; yet, this is the age of experts, and the condition of the Crown Woodlands shows a great want of scientific treatment. Progress is, however, now being made, especially in the Forest of Dean, and the present Commissioners of Woods and Forests are obtaining expert advice in the management of the Crown Forests. No lasting benefit will, however, result, unless there are trained resident foresters to carry out this advice. It would probably be the best policy to select young university men of good general education and with a special bent for a country life and for natural science, and train them professionally at Cooper's Hill. They might then hold subordinate posts under the deputy surveyors in the Crown Forests, and thus acquire sufficient experience to undertake the management of these forests, as vacancies arise.

It is sometimes alleged that the 100,000 acres or so of the Crown Forests form too small an area to warrant any radical change in their present control, but public attention of late years has been drawn to forestry, and it is essential that our Crown Forests should be properly managed, for the following reasons:—

1. The Royal Scottish and English Arboricultural Societies, to which most of the foresters in Great Britain belong, besides many landowners, agents, and nurserymen, go on tour for about a week every summer to visit private and State woodlands, and they should find, at any rate in the latter, models of good forest management. The establishment of a similar society in Ireland would be of great benefit to forestry there, and Ireland would gain equally

with Great Britain if the English Crown Forests, which are easily accessible from Dublin and Cork, were in good order.

2. The students of the Schools of Forestry at Edinburgh and at Cooper's Hill would also benefit by having model forests in this country, where they can learn practical forestry. It has been proposed to teach forestry at Dublin, Oxford and Cambridge in connection with the Schools of Agriculture, and students would greatly benefit by the fact that the Crown Forests were well managed. The advantage of such forests for students at a forest school is admitted by Mr. Munro Ferguson, Honorary Secretary of the Royal Scottish Arboricultural Society, who has set apart an area of about 800 acres of woodland, 20 miles from Edinburgh, in his estate in the Tay Valley, to be properly managed, as well for his own benefit as for the instruction of Scotch foresters. Such an instruction forest should certainly be organised as soon as possible in Ireland.

3. By having model forests in different parts of the United Kingdom, the excellent work done by Sir John Lawes and Sir Henry Gilbert for agriculture in the experimental estate at Rothampstead, might be followed with great advantage to forestry, by the record at each forest of statistics showing the yield of timber and the expenditure and revenue for different species of trees and systems of management.

4. Were our Crown Forests models of good management, and a sound knowledge of forestry taught at our Universities, British Statesmen who become Governors of our Colonies would have no excuse for ignorance of forestry, at present one of the weakest points in our Colonial administration, as was so forcibly shown by Dr. Schlich in his recent admirable lecture at the Imperial Institute on the timber resources of the British Empire, which is now being translated into French, and has appeared in the French forestry magazine, *Revue des Eaux et Forêts.* Owing to our insular ignorance of forestry we have been obliged to borrow trained German and French foresters to supervise the forests of India, the Cape, Natal, and Cyprus, whilst were forestry placed on a proper footing at home, superior men trained in our Crown Forests would be available for such posts, as well as for the charge of important private woodlands at home, and as

professors of forestry in the Colonies, where forest schools must soon be established. The French Government has devoted £20,000 for the Forestry exhibit at the Paris Exhibition next year, which shows the importance our neighbours attach to this industry, whilst the fact that the Japanese Forest Department excelled at the Edinburgh Forestry Exhibition shows what progress has been made by these islanders, who also have their own Forest School at Tokio.

SUBDIVISION OF THE LECTURE INTO HEADS.

I propose, if time will allow, to explain, FIRST, the necessity for an increased area of woodlands in the United Kingdom; SECONDLY, to point out some leading defects in the existing management of our woods; THIRDLY, to give reasons why British forestry should prove remunerative; and LASTLY, to offer some remarks on the present condition and future of forestry in Ireland, a subject on which I cannot speak with much authority, as until my present visit I have only spent a week in Westmeath, in 1890, when I visited the beautiful grounds near Kells of the Marquess of Headfort. Through the kindness of the Irish Land Commissioners, however, I have been permitted to read some very interesting reports on 10,300 acres of woodland in different parts of Ireland, and some reports about the Knockboy plantation in Galway. I have also read the able report on the Afforestation of Ireland, written in 1885 by Dr. Schlich, and two suggestive papers by Mr. W. F. Bailey, Assistant Land Commissioner, on the same subject, as well as the chapter on Forestry in the Recess Committee's report on the Economic Condition of Ireland. During the last two days I have had the privilege of visiting the beautiful woods of Lord Powerscourt, where I have seen that economic forestry can yield good financial results, and at the same time increase the beauty of the landscape. I have also to thank several gentlemen throughout the country who have supplied me with information, and especially Professor Johnson and Mr. Thomas Porter, who have been unremitting in their kindness since I first undertook to lecture in Dublin.

NECESSITY FOR AN INCREASED AREA OF WOODLANDS IN THE UNITED KINGDOM.

Distribution of Woodlands and Waste Lands in the British Isles.

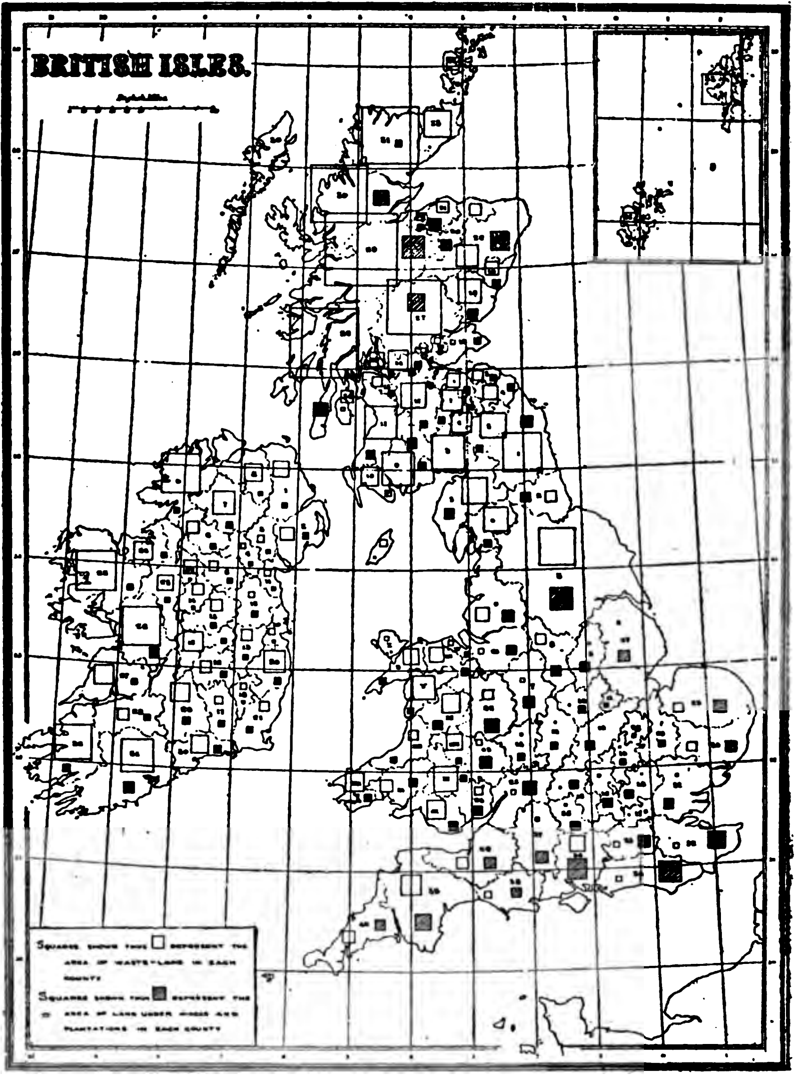
BRITISH ISLES.
Squares shown thus □ represent the area of waste-land in each county
Squares shown thus ■ represent the area of land under woods and plantations in each county

FIG. 1.

Shaded squares represent woods, and unshaded squares waste land, in each county.

It is seen at once from this map, which I prepared from the Agricultural Statistics of the United Kingdom for 1894, and which was published in the *Land Magazine*, in July 1897, that the best wooded counties are in the south and south-west of England and in the Highlands of Scotland; and that Wales and Ireland, though containing large areas of waste lands, are but poorly wooded. In Ireland only 1·5 per cent. of the land is under woods, and over 23 per cent. uncultivated. The woods in England being 5·1 per cent., in Scotland 4·5 per cent., and in Wales 3·8 per cent. of the total areas, while the percentage even for England is less than that of any European countries except Denmark and Portugal.

Altogether there are about 3,000,000 acres of woodlands in the British Isles, and over 28,000,000 acres of uncultivated lands, which is more than one-third of the total area of the country. Dr. Schlich has assumed that of this waste land 4,000,000 acres in Great Britain, and 2,000,000 acres in Ireland can be made available for plantations, altogether 6,000,000 acres, which with the 3,000,000 acres of woodlands we now possess, would give us a forest area of 9,000,000 acres. The additional 6,000,000 acres would yield 9,000,000 loads of wood annually, at 1½ loads of 50 cubic feet to the acre.

AREA STATEMENT FROM THE AGRICULTURAL RETURNS FOR GREAT BRITAIN 1897, AND IRELAND 1898.

Nature of area.	England.	Wales.	Scotland.	Ireland.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.
Field-crops and pasture, .	24,794,000	2,833,000	4,893,000	15,191,000	47,711,000
Mountain and heath land used for grazing, .	2,209,000	1,154,000	9,457,000	2,285,000	15,105,000
Turf-bog, . .	not given	not given	not given	1,167,000	1,167,000
Woods, plantations, and nurseries, . .	1,666,000	182,000	879,000	308,000	3,035,000
Surplus lands including roads and inland waters, . .	3,875,000	605,000	4,226,000	1,382,000	10,088,000
Totals, . .	32,544,000	4,774,000	19,455,000	20,333,000	77,106,000

Now, we import every year, on the average, 9,000,000 loads of wood, worth about £20,000,000, as well as about £6,000,000 of produce from forests, such as wood-pulp, resin, tanning material, &c. Of this, £1,000,000 is for 300,000 tons of wood-pulp, chiefly used in the manufacture of paper. If, then, we deduct from the 9,000,000 loads of timber, 500,000 loads of hardwoods such as teak, mahogany, Australian wood used for street-paving, &c., which we cannot grow at home, this is more than counter-balanced by the wood required for the manufacture of wood-pulp, at the rate of three tons of wood for one ton of wood-pulp, all of which might be produced at home. Roughly, then, 9,000,000 loads of wood, which we can grow at home, is imported every year into Britain, so that by raising the acreage of woodlands in Britain to 9,000,000 acres, we should save most of the £20,000,000 which we now spend annually for our imported wood supply.

Dr. Schlich has shown in his excellent paper on the Afforestation of Ireland, which he published at the request of Lord Carnarvon, in 1885, and also in Vol. I. of the Manual of Forestry, that an increased area of forest means increased work for the agricultural population of these islands, especially in winter, when work is slack, and would introduce a number of industries affording an increased demand for labour. In any case, whether or not we increase our present woodland area, there can be no doubt that what we have should be managed so as to yield the maximum amount of timber of which the soil is capable. I shall attempt to show further on that at present this is not the case.

While, therefore, our Crown Forests should be brought into a high state of productiveness, chiefly in order to serve as models for our statesmen, landowners, land agents, and foresters, we can, as a rule, expect, our landed proprietors to extend their woodlands, *only* when these latter can be found to yield them fair revenues. There are great landowners like the Duke of Bedford, who have managed their agricultural estates in the most liberal manner and have published figures covering the receipts and expenditure for a long term of years to show the results of such excellent management, and Dr. Schlich, who is a most experienced and skilful forester, has drawn up for the Duke of Bedford a management scheme for his large woodland estates of over 8000 acres in

Devonshire and Bedfordshire, which will in time, if properly carried out, bring them up to the high state of excellence which has hitherto prevailed in the farms on the same estates. In Ireland the woodlands of Lord Powerscourt, which have for years helped to supply the Welsh coal mines with pit-timber, and which I had the pleasure of seeing yesterday, may vie in beauty with those of any British landlord, but to render them financially successful much more systematic planting should be carried out; in Scotland, the forests of the Duke of Athol at Blair Athol and Dunkeld, of the Earl of Seafield in Strathspey, and of the Earl of Mansfield at Scone have long been famed, and many others may be added to this list, including those of Lord Powis and Sir Watkin Williams Wynn in Wales. Of the private woodlands in Britain I am chiefly acquainted with the beechwoods of the Chiltern Hills, where the great chairmaking industry is established, and fig. 2, from a photograph by Mr. C. Lyell Grant, represents a pile of chair legs made of green timber in the woods, and there dried before being made up into chairs. Large factories at High Wycombe also buy beech and other wood in the log and work it up into chairs, and larger beech trees are made into wooden shovels and other implements at Chesham. In fact, the extensive beechwoods of Buckinghamshire and Oxfordshire at present afford employment to upwards of 50,000 families, who live in clean four-roomed cottages with fair-sized gardens rented at

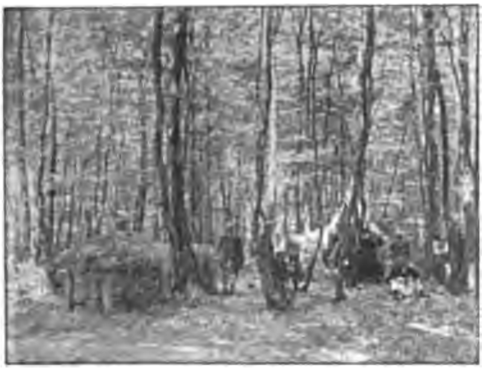

FIG. 2.

about 6s. a week, instead of in the crowded and dingy tenements of our great towns. These beechwoods have been regenerated from time immemorial by natural seedlings from the older beech trees, and are probably almost the sole relics of the extensive forests which covered most of the South of England before the Saxon invasion, and which the farmer descendants of the Saxon and Danish warriors have gradually extirpated. The yield of some of these woods, which are frequently not nearly as dense as they should be, and where sometimes the trees left are too young to bear fertile seed, is about fourteen cubic feet per acre, although French woods on similar soil yield seventy cubic feet per acre, but yet, after all expenses are paid, the net revenue of the Chiltern Woods exceeds 17*s.* per acre, compared with 12*s.* 6*d.* per acre in France, owing to the far higher price obtained for the wood in this country.

It has remained for the men of our day to recognise that agriculture does not pay on all lands, and to stop the further clearing of woodlands where this is the case, and when one reads in the "British Encyclopædia" that the average rental of lands in Sutherlandshire is 1*s.* per acre, it is clear that there are throughout the United Kingdom lands which will yield higher financial returns under a crop of trees than when dealt with agriculturally.

A wise landowner should aim at rendering every class of land on his estate as productive as nature will allow, and there is clearly room for economically productive woodlands on some of the 28,000,000 acres of waste land in the British Isles.

Dr. Schlich has discussed this question at length in the second edition of Vol. I. of the "Manual of Forestry," and comes to the following conclusions:—

1. "As the imports of wood and other forest produce into Britain are very great and it is doubtful whether sufficient supplies can be permanently obtained from abroad, the extension of our woodland area can be strongly recommended, provided it is carried out on lands not required for agriculture. The additional woodlands may reasonably be expected to yield fair returns on the invested capital, if the work, formation, and administration is done economically.

2. "The surplus land in the United Kingdom is so great that extensive areas can be set aside for forests without trenching on the land required for field-crops and permanent pasture.

3. "The increased woodland area will act very beneficially in reducing the effects of strong winds on adjoining lands under cultivation, and in affording shelter to sheep, cattle, and useful birds."

4. Dr. Schlich has proved by calculations, which merit careful study, that lands yielding a smaller net-rental than 8*s.* an acre, can profitably be used in the United Kingdom for the production of timber.

5. "By the establishment of wood industries in the country, which will inevitably follow the increased production of wood, much labour will be kept from emigrating to the large towns."

Hopes may be expressed as to whether a sufficient supply of wood will not always be available from our colonies and from foreign countries, but these hopes will be dismissed after considering from what countries our present supplies come. Leaving hard woods out of the question, the bulk of the demand for building material, railway sleepers, telegraph posts, and paper-pulp is for light, coniferous softwood ; and whereas the supply of hardwood is assured from the luxuriant forests of the tropics, that of softwoods for the world's supply at present comes almost exclusively from the Dominion of Canada and from Scandinavia and Russia. The United States already imports more softwood than it produces, and the demands for timber by the vast and constantly increasing industrial population of that great country is already making huge inroads on the Canadian forests. We receive annually 6,000,000 loads of timber and woodpulp from the countries bordering on the Baltic Sea and Arctic Ocean, but they have also to supply the steadily increasing excess demands of Germany, France, and other European countries; their softwoods go to Australia, to Egypt and South Africa, and to India—in the last case in the form of creosoted railway sleepers—and there is no reason to suppose that the supply in Scandinavia can be increased beyond its present volume, if, indeed, that can be maintained, as most of the forests are in private hands.

The Dominion of Canada and Newfoundland alone remain as certain sources of our future supply of softwoods, and thence at present we get 1¼ million loads annually ; but no proper measures of forest conservancy have yet been adopted in these countries, where lumberers rule the Legislature, and object to the restrictions which a Forest Department would introduce to prevent them from killing the goose which lays the golden eggs, and every year, as I have said before, increasing quantities of Canadian timber are absorbed by the United States. One of the most serious disputes between Canada and the United States is regarding the importation of sawn timber, as the owners of large American sawmills are ready to admit logs without duty, but wish to exclude Canadian sawn material.

Dr. Schlich, in his address to the Imperial Institute in 1897, showed that the Dominion of Canada realised £700,000 a-year from timber, and suggested that they should devote a fair percentage of this revenue, say £70,000 a-year, for the conservation and improvement of their forests, enormous tracts of which are now annually destroyed by fire.

Besides India, where, owing to the wise foresight of Lord Dalhousie, under whom Sir Dietrich Brandis started a splendid system of forest conservancy, which assures a permanent supply of building material and fuel, as well as grass-fodder and thatching material, to that populous empire, the only colonies where forestry is properly supported are Ceylon and the Cape of Good Hope. The High Commissioner of South Africa, Sir Alfred Milner, was brought up in the Black Forest, and favours forestry in the self-governing colonies of South Africa as far as he can, in spite of much opposition from interested people. It is to be hoped that he will be able to restore to Natal the excellent forest management which was introduced there by Mr. Schöpling, but which that colony abandoned in the hope of present gain by the unrestricted felling of their valuable natural woodlands. New Zealand has also abolished the Forest Department which it established, and in Australia, while destroying their natural forests, the Governments are vainly trying to restore a timber supply by means of inadequate plantations.

In the Cape of Good Hope supervision of forest matters is entrusted to a European staff. The Chief Conservator, Mr. E. Hutchins, studied with me at the Nancy Forest School in 1871–72, and two of his assistants have been trained at Cooper's Hill. The yearly vote for forest expenditure is £60,000, and the revenue already £20,000, although the area of natural forests, which are carefully preserved, is comparatively small, and £280,000 of timber is imported yearly. To provide for this deficiency the State is planting 6,000,000 trees annually. The commonest pine is the cluster pine (*Pinus Pinaster*), of which eight tons of seed are sown yearly. To encourage tree-planting, about 400,000 forest plants are distributed yearly to landowners at cost price, and a central seed-store is kept up at Capetown, whence seeds from the warm temperate zone throughout the world, obtained through reliable agents and valued at £1,200, are distributed annually. The imports of timber at Capetown come chiefly from America and the North of Europe. In Capetown the economic value of trees is tested by planting closely quarter-acre blocks of trees, a much better method than merely growing sample trees, as in Britain.

The above remarks, which point to an impending timber famine, should convince us that properly managed woodlands in Ireland must become every year a more and more paying concern, the chief question appearing to be where and how these woodlands are to be formed. Before, however, making any suggestions in this respect, I wish to show why, hitherto, British woodlands have frequently proved unsatisfactory.

LEADING DEFECTS IN PRESENT MANAGEMENT OF OUR WOODLANDS.

The greatest danger to our trees arises from the Atlantic gales, of which we have had such a long experience this winter, and fig. 3 is from a photograph by Mr. Trotter, of Crieff, of some woods which were destroyed by a storm in December, 1893. It is chiefly conifers which are blown down and broken by these gales, and it has been found that the Corsican and mountain pines resist them better than any other conifers. These gales are also greatly dreaded on the Continent, and prove very destructive to the mother

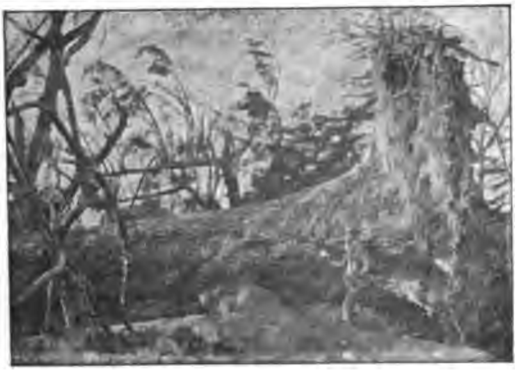

FIG. 3.

trees left to give seed in the fellings for natural regeneration with a shelter wood. In all properly managed forests on the Continent, however, the age-classes of the trees are arranged in cutting series with the older trees to the east, so that the fellings proceed from east to west against the prevailing strong wind, and there is always a belt of trees to the west to protect the isolated mother trees. Wherever clear cutting is adopted, as shown in fig. 4, representing a Saxon spruce forest, where all the trees on a cutting area are felled when mature and the area then re-stocked artificially, the cuttings are also from east to west. In this case, the dense growth of trees render those inside the wood liable to be blown down, if they are exposed by the cutting of an adjoining wood, to the prevailing strong wind. They are tall trees, with elevated crowns, which afford good leverage to the wind, and their crowded state, containing sometimes over 12,000 cubic feet of wood per acre, does not allow for large root systems, that of the spruce being naturally very shallow. The winds from the east are, however, never strong, and by arranging the woods as shown in fig. 5, there

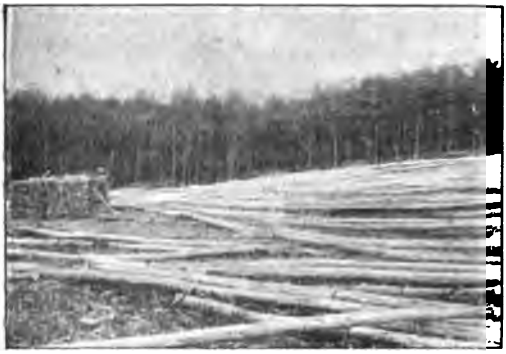
Fig. 4.

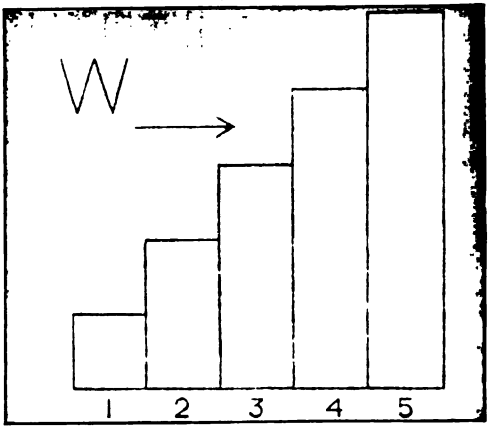

Fig. 5.

being twenty years difference, in descending order, between the average ages of the trees in 1, 2, 3, 4, and 5, and those in 1 being 81 to 100 years old, they are cut in 20 years, say from 1891–1910; those in 2 from 1911–1930, and so on, so that the woods in 5, which in 1890 were 1–20 years old, will be 81–100 years old in 1970, and will be cut from 1971 to 1990, when the diagram representing the ages of the woods will be as follows:—

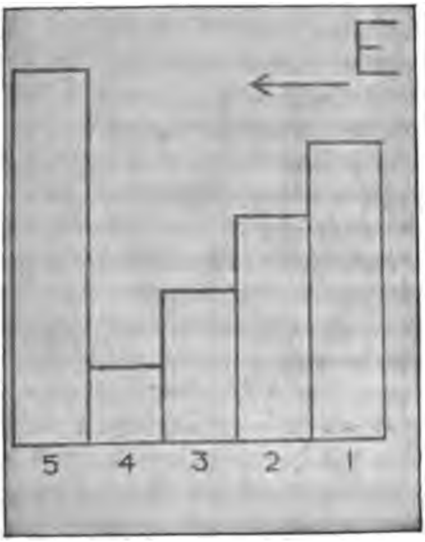

FIG. 6.

The extreme border trees in 5 are strengthened against the wind, either by being kept constantly thinned, so that they are branched down to the ground and have strong roots, or consist of a belt of specially strong wind-firm trees, such as larch or Corsican pines, and it is found that five or six rows of trees form a belt sufficiently broad to resist the wind. Other precautions to enable trees to resist the wind should also be taken, and are detailed in Vol. IV. of the Manual of Forestry, but these precautions were not used in the Scotch Highlands, and consequently several million trees were blown down there in the great December storms of 1893 and 1894. As such ravages introduce attacks of bark beetles and suddenly throw larger quantities of wood on to the market than it can absorb, prices fall, and the owners suffer a very heavy loss.

Another reason why British-grown timber does not compete favourably with foreign timber is on account of the trees being planted too far apart, and the frequently excessive thinnings effected in growing woods.

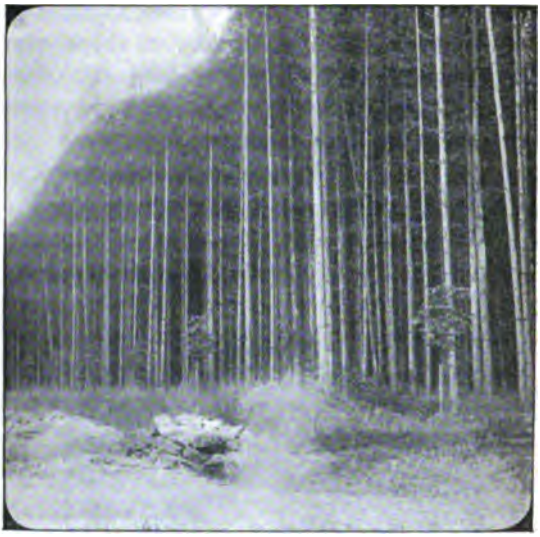

Fig. 7.

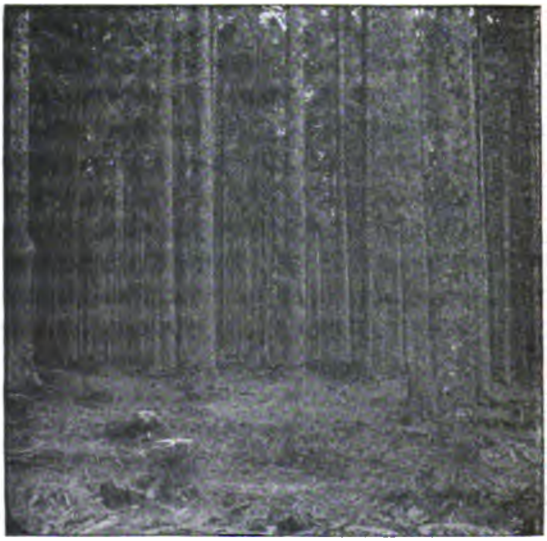

Fig. 8.

Straight clean cylindrical boles are produced in Germany, as shown in figs. 7 and 8, from photographs by Mr. Richardson, of the Royal Botanic Gardens, Edinburgh, but home timber is too often knotty and tapering, forming *coarse-grained* wood, while it is essential that the better class of timber should be *even-grained.* In the case of coniferous wood the annual zones should be narrow. In many of our woodlands there is such a thin stock that the total number of trees per acre is much less than the land can carry, and there is thus only a small yield of mature timber, and that of inferior quality. This open condition is often caused by the early cutting out of larch or pine in mixed woods, when the broad-leaved trees left are not yet mature, but are too far apart to cover the ground, and then under-planting is omitted. The open condition of the stock also affects the soil prejudicially, so that the humus disappears, which is the natural manure of woodlands, weeds spring up and rob the trees of much nutritive matter, and in some cases the soil becomes too dry, in others marshy and sour. All these defects cause a considerable loss of revenue to the proprietor.

Another great cause of reduced prices consists in the fact that there is often no regular sequence of ages in British woods, and that regular annual sales of about the same amount of timber each year cannot be held. I saw this in a marked way at Powerscourt, where plantations have been suspended of late years, but where with steady planting, a clear income of £1500 and more might easily be obtained from the woods. Timber merchants cannot therefore count on a regular annual supply, and consequently prefer to purchase imported timber, whilst in the absence of a regular supply of home-grown timber, industries using wood as raw material are not established. In the Chiltern Hills, there has from time immemorable been a steady annual supply of beechwood, which has allowed a great industry of chair-making and other manufactures to be developed, and the price of standing beech trees there is from 1*s.* to 1*s.* 6*d.* a cubic foot, which confirms the truth of the above statement, there being little demand for beechwood elsewhere in Britain.

Other causes of inferiority are that frequently the plants obtained from nurseries have roots pressed to one side, or have too long internodes, having been kept too long in the nursery. Only sturdy plants with well-developed, compact root-systems should be used. Competition has driven the price of planting material so low, that its production is often conducted with too little care to ensure sturdy and well rooted plants. Obtaining plants from distant nurseries, after long journeys by rail and steamer often affects the plants prejudicially, and it would be well for Irish planters if more home nurseries were established. Mr. Hartland who has nurseries at Cork tells me that he plants about 200 acres a year, besides supplying large numbers of plants to landowners. He says that at present, chiefly conifers are planted in Ireland, to the exclusion of ash, elm, and oak, and that the price of hardwood is already high, and is likely to become higher, owing to the scarcity of hardwoods in Ireland.

The cheap method of planting, termed *nicking* or *notching*, in which a sod is lifted with the spade, the plant inserted with its roots pressed flat, often to one side of the hole, and the sod trodden down over the roots, often produces trees with badly developed roots, which cannot be expected to thrive, or to resist gales successfully. It is better to spend a little more and pit or hole the plants.

Ignorance of the principles of sylviculture is another cause of failure, when mixtures are tried of species which do not accord well together, and above all, plants are put into soils and situations which do not suit the species. I have seen a larch plantation in which three larches are crammed in close together into every planting hole, while few trees require more room than larch. Douglas fir has also been planted in the fens of Cambridgeshire, which are swept by every wind, when the tree eminently requires shelter; larch and Scotch pine, both of which require plenty of light, are sometimes planted under oak; and again, oak trees in the New Forest were planted under Scotch pine nurses, and killed by the shade of their intended protectors.

It is chiefly owing to ignorance of the natural demands of larch on soil and aspect, that larch plantations have suffered so much from disease, so that the production of this valuable timber has been greatly impeded. Larch grows best on well drained sandy loam and on northerly aspects.

Much of the timber grown in British woodlands is used for repairs to fences, buildings, &c., on the estates, and this does not figure in the annual financial returns of the woodlands. This is clearly unfair to the forester in charge, for the real profits of the woods cannot be accurately determined unless every item of increase from them appears to the credit side of the account.

An excessive head of rabbits on an estate is the greatest possible impediment to forestry, and too often in Britain the forester is subordinated to the gamekeeper.

METHODS OF RENDERING BRITISH WOODLANDS FINANCIALLY SUCCESSFUL.

I now come to the third part of my lecture, and propose to show how British woodlands may be made financially successful.

The chief requirement of trees is plenty of moisture throughout the year, and in this respect our climate, and especially that of Ireland, is admirable. The winters are generally mild and short, and in fact the chief difficulties to contend with are the strong westerly gales, and the occurrence of spring frosts up to May and even June, which, however, are less felt in Ireland than in Great Britain, as the fuchsia hedges in Westmeath testify. I have lately seen how our moist climate can enable trees to grow on most unpromising soil in the case of plantations of about 400 acres, made in the Bagshot sands district in Surrey. Here there is a deep sand covered by a loose shingle of flints, from which it is separated by an impermeable pan, and the surface is capped by a few inches of black heather soil, generally bearing a crop of heather, though sometimes the soil is so poor that a whitish lichen, called Iceland moss, appears to the exclusion of the heather. This very unpromising site has recently been planted by Dr. Schlich with Scotch and Weymouth pines, and in order to do this successfully, pits 1¼ feet deep, sometimes 5, and sometimes 4 feet apart, were dug, and crowbars used at the bottom of the pits to break through the pan, which formerly made a morass of the place in wet weather, and left it very dry, even for Scotch pine in prolonged dry weather. The roots of the plants are now in the sand of the subsoil, and the heaviest rain at once drains through, whilst the plants are most flourishing and with strong leaders. There are pine-trees about eighty years old on adjoining land, where the pan is somewhat deeper down, which are worth about £100 an acre, besides the value of the thinnings, and all stems removed in the latter, which are three inches in diameter at base, can be sold at 20*s.* a hundred, whilst larger poles fetch higher prices, so that the returns from thinnings which may be made every five years, from the age of twenty years, amounts to a respectable figure.

Dr. Schlich has calulated that if a pine wood is grown for pit timber, starting with 3500 plants an acre, the thinnings made at the age of 20, 25, and 30 years will sell altogther for about £12 an acre, and will leave about 750 trees per acre, which at the end of 40 years will be 51 feet in height and 6½ inches in mean diameter, representing a volume of about 3200 cubic feet per acre (quarter-girth measurement). This at 5*d.* a cubic foot is worth £66; and allowing £6 for planting, and 3*s.* a year for rates, maintenance, and supervision, at compound interest at 2½ per cent., corresponds to a soil rental of 13*s.* an acre annually.

If there is a demand for larger timber, the 40 years old Scotch pines may be thinned and underplanted with Weymouth pine which will grow up under their shade, and the whole wood kept up with the necessary thinnings till the age of 80 years, with better financial results than those given above. When the older wood is mature, the Weymouth pine may be cut out, and the Scotch pine regenerated naturally, so that the expenditure on planting could be saved.

This is an instance of how inferior soil quite unsuitable for agriculture may be utilized; but better returns will be obtained, should the soil be good enough to grow larch, Douglas fir, silver fir, or Spanish chestnut, all of which species flourish in Ireland. Larchwoods 45 years old, in Pembrokeshire, were sold in 1895 for £70 an acre, and some Irish larchwoods 64 years old in 1894 produced £127 an acre, but in neither of these cases is the value of the previous thinnings given. Spruce might also be grown for paper-pulp, but this species generally produces a spongy wood in our climate, being too soft for ordinary building material, though it may be improved in quality by keeping the woods dense.

For the production of oak timber, by private owners, the system of coppice-with-standards is probably the best to adopt, and fig. 9, from a photograph taken by a son of Mr. Stafford Howard, Commissioner of Woods and Forests, shows what splendid oaks are grown under this system in French Flanders near the town of Valenciennes. The largest tree in fig. 9 was sold as it stood for £45.

In the management of coppice-with-standards, it is essential that the underwood should be of a class to command a ready sale, and near London ash underwood proves most remunerative, and ash underwood has been recently sold in Somersetshire for £12 an acre. The standards should be chiefly oak, and the rotation of the underwood not less than 12 years. It should be remembered that the longer the rotation of the underwood, up to 30 years, the more the soil is enriched by dead leaves, the greater the value of the underwood, and the cleaner and longer the poles of the standards. In the vicinity of coal mines, where the underwood serves for pit props, the rotation should not be less than 25 years.

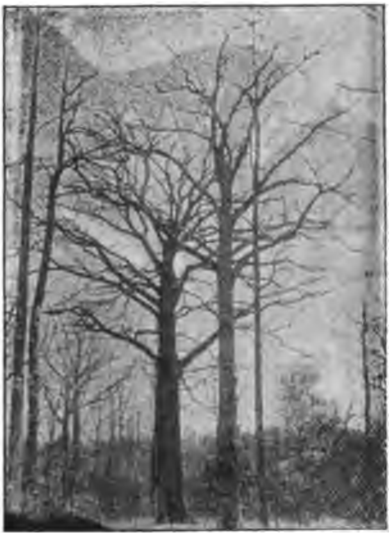

FIG. 9.

As regards the standards which are felled immediately after the underwood, there should be a regular succession of ages on the ground, and, say, 20 saplings planted for every mature oak felled.

Supposing the rotation of the underwood to be 25 years, there should be per acre on a felling area:—

60 sapling oaks, . .	5 years old.
30 oaks, ...	30 „
20 „	55 „
5 „	80 „
1 „	105 „

As soon as the underwood has been removed, all defective standards and those overcrowding one another should be felled, and we might thus fell:—

1 oak,	105 years old,	worth £16
2 „	80 „	„ 20
5 „	55 „	„ 10
5 „	30 „	„ 2
13 oaks,		worth £48

Then adding £12 as the value of the underwood, we have £60, the value of one acre of felling every 25 years, which, allowing £2 for the cost of planting 60 sapling oaks, and filling up gaps in the underwood, gives £2 6*s.* 8*d.* per acre, as the annual yield of the wood without deducting rent, rates, taxes, and supervision, supposing it to consist of 25 acres, on one of which fellings are effected annually.

The best results I have hitherto heard of in England from coppice-with-standards are in the Hazleborough wood belonging to the Crown, where an area of 430 acres planted in 1830–35 yields on the average £1 1*s.* 11*d.* per acre after all expenses have been paid, but here the underwood is of little value, and better results may be obtained with a 25 years' rotation and well distributed standards, though it is of course essential that the soil should be good enough for oak to thrive.

On wet soil, as in the Netherlands, ash or poplar standards are largely grown by private owners over alder coppice, and I have seen in the Rhine Valley alder underwood, 30 years old and 60 feet in height, under magnificent oak and ash standards.

Silver fir is a tree which is largely planted in Normandy by private landowners, and it grows admirably in the South of England and everywhere in Ireland, yielding a better timber than spruce, and a larger volume than any other European tree, up to 17,000 cubic feet per acre. Fig. 10 shows some fine silver fir poles growing at Freudenstadt in the Black Forest. Broillard recommends that this tree should be grown in the same way as beech in the Chiltern Hills, *i.e.*, in the selection system of high forest. He gives an example, a wood of 250 acres, allowing the trees to attain a girth of 4 feet at chest height, which on suitable soil would not require more than 60 to 70 years. In a wood of this description he would fell 150 trees annually, yielding about 10,000 cubic feet worth at 6*d*. a cubic foot, £250 per annum. He would divide the area into 8 blocks, in each of which in succession the 150 trees would be felled annually, and, provided the fellings were carefully made and no sound tree felled under 4 feet in girth—all healthy dominated trees being left to grow up and fill the gaps, whilst all defective, and dying or overcrowded stems are removed—such a forest will maintain itself indefinitely by natural regeneration, for young silver fir requires shelter, and will grow up into large trees, if gradually allowed more light from above.

Similar rules apply to selection forests of beech, and we have seen how useful and profitable this wood becomes when grown in masses, as in the Chiltern Hills. The Continental system of growing beech by having a regular succession of age-classes on the ground and regenerating the mature crop by successive fellings, when the shelter trees left to sow up the ground and protect the young crop from frost and drought are gradually removed, is shown in figs. 11, 12, 13 from photographs taken at Lauenan, near Hanover, by Mr. Richardson of the Royal Botanic Garden, Edinburgh.

Spanish chestnut is extensively grown in Surrey, both in high forest with larch and beech, and as simple coppice. 159 Spanish chestnut trees, 90 years old, have recently been sold for £318 at Thorpe-place, Chertsey. They were growing on 8 acres of ground, and a fair crop of trees is still left on the area. Chestnut coppice, 10 years old and 30 feet long, the thickest poles being over 1 foot in girth at the base, sells at about £12 an acre near Cooper's Hill, and is chiefly used for hurdlemaking.

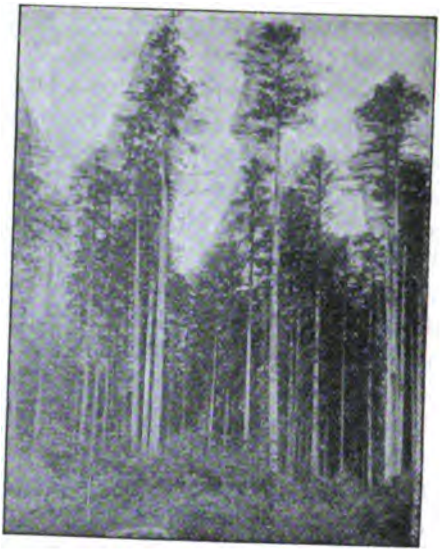

FIG. 10.

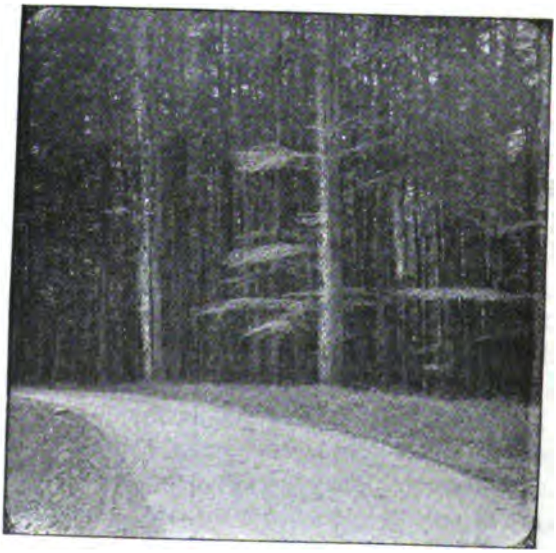

FIG. 11.

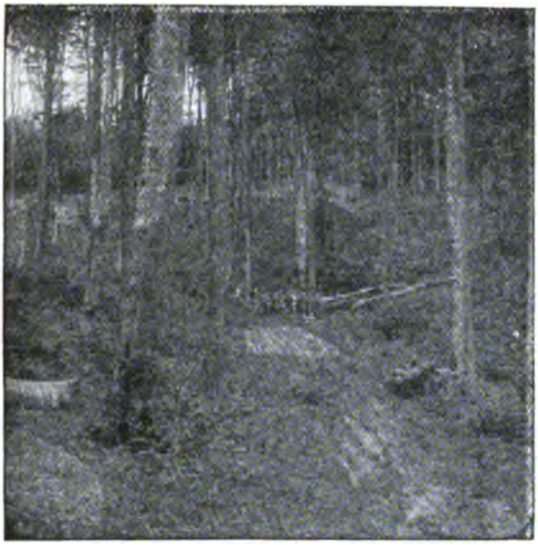

Fig. 12.

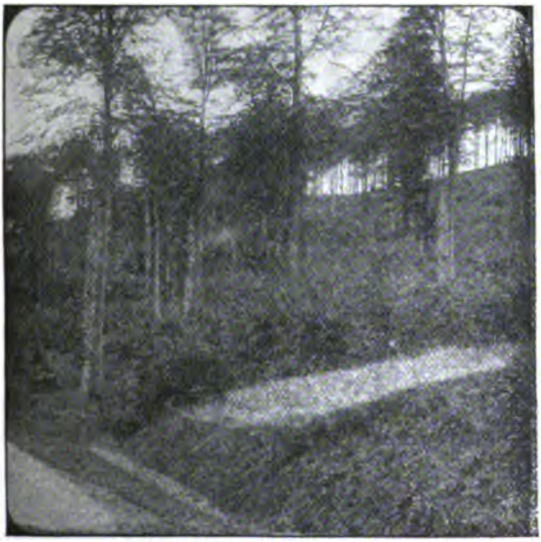

Fig. 13.

FORESTRY IN IRELAND.

I now come to the last division of my lecture, FORESTRY IN IRELAND, which I subdivide into two heads:—

I. Notes on Irish Woodlands;

II. Proposals for State support to Forestry in Ireland.

NOTES ON IRISH WOODLANDS.

Thanks to the kindness of the Irish Land Commissioners, I have seen reports by twenty Irish landowners, respecting woodlands in various parts of Ireland; they were written in 1891, in reply to a list of questions circulated by the Land Commission with the view of obtaining detailed information on the subject of Irish Afforestration. These reports contain, I believe, the best available account of Irish Forestry.

I have to thank the writers for allowing me to make use of their knowledge.

The total area of woods and plantations reported on is about 10,300 acres, and they consist chiefly of plantations of conifers, pure, or mixed with broad-leaved trees, and only in a few cases of natural woods. The conifers chiefly planted are larch and Scotch pine, with some silver fir, spruce, and Austrian pine; the latter is said to have little value, but the extension of Corsican pine is recommended. About 50,000 Douglas fir have been planted at Kenmare, and this species grows rapidly and produces a very large volume of timber per acre.

The broad-leaved species are chiefly ash and oak; at Kenmare there are 1000 acres of alder; elms and sycamore are less common, but valuable; birch is everywhere indigenous, and beech grows well, but is not generally saleable. The Earl of Erne has 600 acres of coppice with standards, cut with a regular rotation, the length of which is not given; in this, ash is the most valuable wood both as standards and underwood. It is however stated that though equal areas of underwood are cut annually, and the standards are then thinned and the produce of the fellings auctioned, there is little profit above the cost of cutting. Perhaps the rotation is too short and the stock may require improving by planting more ash and cutting out inferior species.

At the Earl of Meath's place, near Bray, there is a fine row of old sweet chestnut, and I am surprised not to hear more of this valuable wood in Ireland, where it ought to thrive, except over limestone rock.

The plantations reported on are generally very healthy, but near Naas, conifers are reported to grow well up to 60 years and then to fall off; coniferous plantations also suffer from beetles if planted too soon after a similar crop has been felled. On moory soil, ash, larch, and spruce sometimes suffer from root-rot. Larch blister is referred to in one case only. Goat-moths occasionally attack oak and ash, and aphis—silver fir and spruce. The cold west winds in spring redden the foliage of spruce when grown in the open, but well sheltered spruce appears to be quite healthy.

The character of the soil varies considerably in the different plantations, but is chiefly characterised as dry mountain land, peaty moor land, or drained bog.

One landowner gives the following very valuable information regarding plantations on peaty ground:—

> "The trees to plant on peaty ground are larch, oak, Scotch pine, alder, ash, and sycamore. They should be planted by holing. The peat should be cut away down to the last spit of 1½ feet above the subsoil, which may be gravel, limestone, or marl (the last is the worst). The plants should be short and thickly planted. Drainage most carefully attended to, and out-falls always kept open. A few large drains are better than many small ones. The planting should follow the cutting out of the bog, and the cutters should always leave 1½ feet of bog. Once the roots have reached the subsoil the growth is rapid, and the wood remains sound. Such plantations should be considered as crops. That is, after a certain time, they should be cut down and the land given over as arable, or for pasture. It will be found that grass grows under the trees and replaces heather, &c.
>
> "If a certain number of hardwood trees are left after the conifers are cut, the land can be used for grazing, and the trees will not suffer. If the plantation is to be used as arable land, the trees' roots must be dragged out, or charred, as in American backwoods. This is easy work, owing to peaty top-soil. The leaf manure in such cases will be found to have greatly improved the soil, and good land results.
>
> "Large areas might thus be reclaimed along the lines of the chief Irish Railways, but special rates for transport of timber must first be arranged; now they are prohibitive, especially on the Great Southern and Western Railways."

Mr. Kinahan, of Woodlands, Fairview, informs me that many plantations were made in bogland at the beginning of this century, and, wherever the boundary ditch has been kept open, are good woods now, but wherever this has not been done they have deteriorated.

The following trees are chiefly recommended for peaty lands:—Scotch pine, alder, birch; Austrian and mountain pines do well, but yield inferior wood, Corsican pine is better. There is a difference of opinion about larch, which does not generally thrive in bog-land, but if the land is treated as already advised, larch will prove successful.

In order specially to study the nature of plantations on bog-land, Dr. Schlich visited some bogs near Bremen and Hamburg, where extensive plantations have been made, and has published some valuable notes on the subject in his report of October, 1895, on the Knockbog plantation. He considers that on old drained and manured bog-lands, irrespective of their depth, profitable forestry can be carried on; on newly-drained bog-lands profitable forestry ceases with a depth of bog of about three feet, unless such land is manured and improved by bringing mineral soil on to it. Birch does best on the deeper bogs, and splendid oaks grow where the bog is less than two feet deep, and fairly good oaks on bog not more than three feet deep. Weymouth pine appears to do well on these German bogs, then Scotch pine and spruce, but there is little larch. In any scheme for planting cut-out bogs in Ireland, it must not be forgotten that where turf fuel is required the permanent maintenance of the bog should be secured. I have dealt with this question in Vol. V. of the "Manual of Forestry."

Valuable information is supplied in the reports of the Irish landowners regarding the effects of re-planting with the same species, after larch, Scotch pine, or spruce have been felled, and the Marquis of Waterford recommends waiting one or two years after larch and four or five years after Scotch pine or spruce, before re-planting the area. At Curraghmore, on high dry land, the pine weevil destroyed nearly all the larch and Scotch pines planted and re-planted in three successive years, after a crop of Scotch pine had been felled. The ground was then left fallow for four years, and when again planted produced a most flourishing crop of trees. Fallow may not, however, be necessary on very good soil, and may be avoided by extracting the old stumps in which the beetles breed.

The cost of plantations varies from 15*s.* an acre without the cost of plants for nicking, to £12 7*s.* an acre for pitting. The average cost, including plants, is £5 an acre, but the distances apart of the plants are not given. Eight feet apart, mentioned in one case, is too far, three and a-half or four feet being better, the former for Scotch pine, which forms big lower branches. A common mistake in Ireland is to plant too far apart, and not to give sufficient depth to plantations, which, when skimpy, are useless.

Dr. Schlich estimates the cost of draining and fencing at £2 an acre, and of planting, including plants, at £2, the amount usually spent in Scotland on notching in two-year-old plants. Where larger plants are used and pitting adopted, planting and plants should cost about £4, and the total cost, including drainage and fencing, would not exceed £6 an acre.

It is stated that in drained bog it is best to pit and put in a shovelful of gravel before planting. Nicking is said to render plants firmer against the wind on hill-sides, but this is contrary to Scotch experience. The plants are chiefly purchased, probably from England or Scotland, and must suffer by being transported so far, but near Boyle there is a private nursery of 12 acres, from which, besides supplying 1067 acres of the estate woodlands, about £100 worth of plants are sold annually.

The cost of cleaning plantations from furze, etc., up to the age of twelve years, varies from 6*s.* to £2 10*s.* an acre. Farmers would readily cut and remove grass from plantations, but fears are expressed that they would cut the plants. Surely this could be avoided by mutual agreement, if they got the grass gratis.

There is a general concensus of opinion in favour of larch and ash as the most profitable timbers to grow. Ten years old larch poles from thinnings sell at 1*s.* and 1*s.* 6*d.* a dozen, and older larch poles at £5 per 100 and up to £40 an acre. The best report of sales of larch I have hitherto heard of has been very kindly placed at my disposal by Colonel Bayley, of Killarney Hall, Bray. The trees were growing on land of good quality, but too steep for any purpose but planting; the heavy timber of nine inches diameter at the small end, and over, was sent to Liverpool, the tops were sawn into pit sleepers, and altogether 138 tons were sold, the cost of marketing being 10*s.* a ton, including all costs. The price realised was, after deduction of 10*s*. per ton expenses, £125, while there remained on the area 70 larch and oak and ash, worth £50, and £15 realised as value of tops; total value of 1½ acres of timber, 64 years old, £190, or £127 per acre.

At Powerscourt larch plantations 35 years old, where the trees are 1½ feet in girth and 50 feet high, can be sold as they stand for £50 an acre, a soil rental of 13*s*. an acre, while after conversion of timber at the sawmills on the property, the price is trebled per cubic foot, the increased cost being not more than the original value of the wood as sold standing.

Ash thirty years' old and upwards sells at 1*s*. a cubic foot; it is used for wheelwrights' work, staves for butter-tubs, and boards for general purposes. Alder sells readily for flax-spinners' rollers, and as well as birch, for clogs, and all hard-woods sell well when there is a bobbin factory handy. Elm is in demand for wheelwrights' work and coffin-boards, and sycamore for mangles, rollers, &c. Large oaks sell at 2*s*. 6*d*. a cubic foot, but are unfortunately rare; whilst oaks for weir-poles, 23 feet long, sell at Limerick at 20*s*. a dozen. Beech sells at Limerick at 15*s*. a ton for butter-firkins, but is chiefly used for fuel. At Dromore, Co. Kerry, the value of fifty years' old mixed plantation is put at £80 per acre.

Whenever there is a saw-mill on the property, the disposal of produce is much facilitated. At Dunmore, Queen's County, a 36-inch circular-saw is in constant work with four men, and the demands for wood from farmers and tradesmen is larger than can be supplied, much timber grown outside Mr. Staple's estate being bought and utilized. Oak paling posts, 6 feet long, sell for 6*d*. each, of larch, 4*d*., and other firs, 3*d*.; ash felloes cut with a hand-saw, 4*s*. a set; ash handles made by a special machine, from 1*d*. to 3*d*. Larch is made into carts, barrows, &c. Spruce and Scotch pine into boards and rafters, hurdles of larch and Scotch pine, 2*s*. 6*d*. each. Beech is cut up into fuel, and elm into coffin-boards.

The late Mr. R. Mahony had a saw-mill worked by a turbine at Dromore, and sold native dressed wood at two-thirds of the rates for foreign timber from merchants' yards. Another proprietor had also a saw-mill, and sold manufactured wood at 45*s*. to 50*s* a ton.

Great complaints are made at the exorbitant charges for timber-carriage by rail, or canal, and the monopoly exercised by the G. S. & W. Railway in the south of Ireland, is said to be disastrous and prohibitive of all industrial enterprise. The acquisition and consolidation of the management of Irish railways by the State would reduce direction-charges, and greatly favour agriculture and forestry.

As regards the production of osiers, it is stated that basket-makers frequently steal all they want along river-sides. Lord Kingston has started an osier-bed near the Shannon, and gets 7*d.* per bolt of 100 osiers. They are used as *scallops* for thatching as well as for baskets and hampers. It is also stated that ash underwood is stolen for scallops, but the best way to prevent timber-theft is to compete with the thieves by selling sufficient produce of the kinds stolen annually to the highest bidder. In one case, £2 10*s.* an acre was obtained annually by the sale of dog-wood, grown on wet lands along streams, and osiers would probably pay still better. There appears to be plenty of land suitable for osier-beds, but people are afraid of the competition of imported basket-work. Maiden willows are easily grown on wet land, and sell well for cricket-bats when about twenty-five years old.

Malicious injury to plantations is quite exceptional, though trespass is not uncommon, and the woods naturally require watching. The late Mr. Mahony of Dromore stated that goats sometimes damage plantations, and he did not plant where there are large flocks of them. He found that the people appreciate the benefits of early thinnings, which he gave them gratis, and also from the dressed timber he sold them from his saw-mill. During the fuel famine in the winter of 1891, the woods at Dromore were the means of saving the people from perishing. They attended on fixed days, both tenants and strangers, and wood fit for nothing else was given to them gratis. Not a trespasser entered the woods on other days, and the people were most grateful. This shows what a resource woodlands are, when the turf is frozen and coal is not available.

As regards shelter against wind, larch *thinly* grown is recommended, but Austrian pine, which, however, has little sale-value, and Scotch pine have most supporters, and beech wherever it will thrive. Sycamore is very windfirm. On poor land, Scotch pine and birch form useful screens. Dr. Schlich states that at Knockboy Mountain, Austrian and Scotch pines best resist the gales and salt spray. In Scotland, Corsican pine has been found to withstand gales best; it did not succeed at Knockboy, but the plants may have been bad. There is a general consensus of opinion, that cattle benefit greatly by the shelter which plantations afford, and that arable and pasture land are thus also improved.

Game rents in certain districts might be improved by increased coverts, especially if the latter are extensive; but in the interests of game in Ireland, dog-licenses should be raised from 2*s*. 6*d*. to 7*s*. 6*d*., and men with 10*s*. licenses not allowed to shoot game. As in the Windsor Forest, so in the many private woodlands in the United Kingdom, the work of the forester is too often subordinated to that of the gamekeeper, and forestry and agriculture is injured by the wholesale destruction of birds of prey which keep down mice and other vermin and wood-pigeons which devour the crops. Woods on the Continent are managed so as to pay their owner well, and yet contain a good supply of game; but this is not compatible with a large stock of rabbits.

As to the land available in Ireland for planting, I have already given a suggestion about planting bogland along the railway lines, and cut-out bogland, wherever it exists, can be thus utilized. There appears to be plenty of mountainous land available all round the Irish coast, but it is said that tenants would require as much for the tenant-right as would cover the cost of fencing, planting, and draining. They will, however, only lose by opposition to the sinking of capital in the country which plantation implies, and a *modus vivendi* between the demands of graziers and foresters can surely be arrived at.

PROPOSALS FOR STATE SUPPORT TO FORESTRY IN IRELAND.

Here ends my summary of the reports of Irish land owners, and I propose in conclusion to discuss some suggestions which have been made as to State support to Forestry in Ireland. Dr. Schlich knows of immense tracts in Galway let for grazing at 3*d*. an acre, in which plantations might be started to supply wood-pulp, birch for bobbins to replace the thousands of tons annually imported from America, pit timber, &c. The experience gained at Knockboy has been disappointing, but there is no need to plant on land exposed to salt spray, and the work there was not started, as Dr. Schlich suggested, after detailed examination of the ground and preparation of a scheme by an experienced forester. Until the Land Commissioners make up their minds to employ a professional forester to draw up schemes for plantations by State agency, and to supervise the execution of any such schemes, plantations by the State should not be undertaken. I believe that it would be greatly to the interest of Ireland that State forests should be provided in different parts of the country, but for this to be successful a considerable sum of money must be supplied annually, the interest on which will not begin to come in for 20 years or more.

As regards State support to plantations by private agency, I have seen a recommendation that the provisions of the Land Improvement Acts should allow loans to be made to land owners, free from the limitation, that the plantation must be " for purposes of shelter." Dr. Schlich further suggests :—

1. The amount advanced should be sufficient to meet the cost of draining, fencing, and planting.

2. The proprietor should pay 2½ per cent. annually on each advance until the plantation begins to yield a return, and after that a sufficient percentage should be paid to repay capital and interest within a limited period. Thus, in the case of larch or Scotch pine, 2½ per cent. might be paid during the first 25 years, and then 7 to 10 per cent. until capital and interest are paid off.

3. Government should have a lien on the plantation until the advance is paid back, and a certain control over the management.

This last clause would clearly require a professional forester to be attached to the Land Commission in order to inspect private plantations and advise proprietors who wish to plant, as is already done in the United States.

Mr. W. F. Bailey, the legal Assistant Land Commissioner, has published in the *Journal* of the Statistical and Social Inquiry Society of Ireland in August, 1889, and July, 1890, two very suggestive papers on the importance of Forestry to Ireland. He states that the Land Purchase Acts have hitherto had disastrous effects on Irish woodlands:—

> "No sooner does a farmer, in many instances, become the purchaser of his holding than he assures himself of his emancipation by cutting down all the trees on the farm. In some cases also when entire estates are sold, on which there are considerable plantations not attached to the holdings of any particular tenants, the owner having no further interest in the place, proceeds to sell the timber to the highest bidder regardless of the consequences to the neighbourhood."

Mr. Bailey gives several instances of this deplorable action in Meath, Derry, and Monaghan.

He also says that:—

> "In many parts of Ireland a great part of the value of the holdings depends on the right of cutting turf. Most large landowners preserve for each tenant on the estate proportionate rights of cutting turf on the landlord's bog. Under the Land Purchase Acts there is much danger that these turbary rights may cease to exist. Turf-bogs will, in case of sale, be divided up between the farms of adjoining occupiers, who will, after a time, acquire a monopoly—doubtless beneficial to themselves—but ruinous to their neighbours. Already in the North of Ireland, the peasantry on an estate sold under the Purchase Acts have been prohibited by those of their number who had obtained possession of the turf-bogs from getting turbary, except at exorbitant charges."

Mr. Bailey also says that the turf supply in Ireland is rapidly diminishing, and that after a certain number of years the people will be obliged to plant trees for fuel purposes, necessarily a slow measure and requiring system and care. He therefore proposed that:—

> "In the Land Purchase Act before Parliament in 1890, a clause should be inserted reserving from every farm sold under the Act, all woodlands, the continued existence of which would be of advantage to a district.
>
> "In the measures for the reform of local government of Ireland, care should be taken to give power to the new local bodies to undertake the planting of waste lands and for acquiring such lands as may be suitable and desirable for the cultivation of timber."

Supervision over all lands so planted should, in my opinion, be exercised by the Agricultural Department, which would naturally employ an expert for the work, corresponding to the chief of the Forestry Branch of the United States Agricultural Department.

I have read with great interest the splendid report of the Recess Committee on the establishment of a Department of Agriculture and Industries in Ireland, which contains a mass of extremely useful information on the industrial development of other European countries; and no one can doubt that such a system must if boldly and persistently carried out, in spite of any preliminary difficulties which may arise, have most beneficial results in Ireland. It is probably due to an oversight in that report, that in the chapter on Forestry no mention is made of the able report on the Afforestation of Ireland written by Dr. Schlich in 1885. Tenants and graziers who would oppose the planting of 2,000,000 acres of the waste lands of Ireland, must be extremely short-sighted people; the greatest of all wants in Ireland in an investment of capital of this kind, an investment which will yield an enormous return in affording labour to the people, and in supplying raw material for industries which cannot prosper without it, as well as timber for export, and for the improvement of farms and dwellings.

It is clear enough that to restore Ireland to its formerly well wooded condition, a Forestry Branch of the forthcoming Board of Agriculture must be started with a competent man at the head of it, and that advances for planting must be made by the State to landowners and local authorities, the advances being repaid gradually, and the woodlands meanwhile being under State supervision.

At the same time, Forestry instruction should be provided, which could be best done in Dublin in connection with the College of Science, as Forestry is an industry, based on a knowledge of botany, soils and entomology, whilst practical instruction in surveying and levelling is also necessary, as well as a certain acquaintance with law. It is essential for the success of a School of Forestry that a sufficient area of woodlands, say 1000 acres, should be set aside for the outdoor instruction of students, and this might perhaps be provided, as has been done by Mr. Munro Ferguson for the Edinburgh students, by some of the landowners in Wicklow.

A good practical man would be required to take charge of the school forest, who is acquainted with modern forestry, and would manage a nursery for forest plants, and look after the woods, but all the profit from the latter should go to the owner, unless a sufficient woodland area could be leased, or purchased, by the State. A good feature in connection with the school forest would be the planting of sample plots with different species of trees, and careful record of the conditions of their growth and yield.

We have now an English Manual of Forestry, and plenty of experienced men, who have studied forestry abroad, and the Forestry Branch at the Royal Indian Engineering College can compare favourably with any forest school in the world, while Dr. Schlich, the principal professor of Forestry there has certainly a wider experience in his subject than any forester in France or Germany. Unless Ireland is to continue to be the least wooded country in Europe, the Government should follow Dr. Schlich's advice contained in his 1885 Report on the Afforestation of Ireland, for which he received special thanks from the late Lord Carnarvon.

III.

ON THE ADHESIVE AND OTHER PHYSICAL PROPERTIES OF CERTAIN COPPER PREPARATIONS USED FOR SPRAYING POTATO PLANTS.

By RICHARD J. MOSS, F.I.C., F.C.S., Chemical Analyst to the Royal Dublin Society.

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The precise nature of the effect produced by spraying preparations on the fungus of potato disease is, I believe, unknown. Experimentalists are agreed, however, that copper is the active constituent of the various copper preparations used as fungicides, some authorities maintaining that so small a quantity as two or three parts in ten million will kill the spores of mildew. Apart from this toxic effect, it is said that spraying with Bordeaux mixture has the effect of promoting a marked development of chlorophyll granules, and increasing the growth of certain cells in the leaves.[1]

However the effects are explained, the fact remains that spraying potato plants with copper preparations has been found to increase the power of resistance of the plants to the attack of *Phytophthora infestans*, to prolong the life of the plants, and increase the crop of sound tubers. It is therefore a matter of considerable agricultural importance to determine which is the best kind of spraying preparation. If the beneficial action is due to copper, it is manifest that preparations easily removed from the plants by rain must be inferior to those that remain on the leaves under the same conditions, provided, of course, the copper is in each case in a form capable of exercising the desired effects.

Experience shows that in order to secure the best results it is necessary that the leaves of the potato plants should be covered as uniformly as possible with a fine adhesive deposit of the copper compound. The copper compound is used either in solution or suspended in water. In the case of solutions it is only necessary to ensure that the deposit produced in spraying shall have the necessary power of adhering to the leaves, and resisting the action of rain.

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[1] E. G. Lodeman: Ontario Agricultural College Report, p. 125; Annual Report of the Department of Agriculture, Ontario, 1897.

Subsidence.

In the case of compounds in suspension, such as are almost exclusively used in Ireland, it is necessary to take into consideration the tendency of the suspended matter to subside. The rapid subsidence of some preparations has produced most unsatisfactory results, one part of the crop being sprayed with more than its share of the copper compound, and the remainder with nearly pure water. This difficulty led to the introduction of of mechanical contrivances for the purpose of keeping the spraying mixture agitated. It is obvious that spraying preparations in which the solid matter remains uniformly distributed, without agitation, have a distinct advantage over those which must be kept constantly stirred up. The following experiments were made with three spraying preparations in common use in Ireland, viz., (1) Bordeaux mixture, (2) Burgundy mixture, and (3) a well-known ready-made spraying powder. Equal volumes of the three mixtures, immediately after preparation, were placed in cylindrical glass vessels. Each mixture contained exactly the same quantity of copper, *i.e.* the quantity contained in a two per cent. solution of copper sulphate. The mixture in each cylinder was thoroughly shaken up, and then allowed to stand for five minutes. The upper half of each mixture was now siphoned off, and the quantity of copper in it was determined, with the following results:—

Copper in the upper half of Mixture after standing for 5 minutes.

Bordeaux Mixture.	Burgundy Mixture.	Ready-made Spraying Powder.
0·246 grm.	0·242 grm.	0·008 grm.

If the copper compound in each of the mixtures had remained in a state of uniform distribution, the upper half of the liquid in each case would have contained 0·254 gramme of copper, and the lower half would, of course, have contained the same quantity. Assuming the total quantity of copper in each mixture to be 100 parts, then the following figures represent the quantity per cent. of copper in the upper and lower halves of each cylinder after the lapse of five minutes:—

Percentage of Copper after 5 minutes subsidence.

	Bordeaux Mixture.	Burgundy Mixture.	Ready-made Spraying Powder.
Upper half, . .	48·4	47·6	1·6
Lower half, . .	51·6	52·4	98·4

It will be observed that the copper in the mixture prepared with the ready-made spraying powder had almost completely subsided from the upper half of the liquid in so short a period of time as five minutes. The other preparations show a very small amount of subsidence. If the Burgundy mixture be prepared by adding just the right quantity of sodium carbonate to completely decompose the copper sulphate, and the mixture is left standing perfectly undisturbed for a sufficient time—half an hour or so, according to the temperature—the gelatinous precipitate, instead of subsiding, begins to rise in the liquid. The explanation of this effect is that carbon dioxide is disengaged in the reaction, and the bubbles of gas becoming entangled in the gelatinous precipitate of copper carbonate and hydroxide cause it to rise in the liquid. The reaction may be represented as follows:—

$$2CuSO_4 + 2Na_2CO_3 + H_2O = CuH_2O_2, CuCO_3 + CO_2 + 2Na_2SO_4.$$

By employing a sufficient excess of sodium carbonate, say, three parts of the crystals to two of copper sulphate, as in ordinary Burgundy mixture, there is no actual disengagement of gas, and the gelatinous precipitate subsides, though very slowly.

Adhesion.

The adhesive properties of some of the preparations used for spraying have been investigated by MM. Aimé Girard, J. M. Guillon, G. Gouirand, and others.

M. Aimé Girard[1] employed potato plants in his investigations. Plants of the early variety known as "Aurora" were grown in pots, and were treated in the following manner:—Twelve pots, with potato plants in full foliage, were arranged as nearly as possible as the plants would be under ordinary conditions, and the plants were then sprayed with one of the preparations under investigation. The pots were then returned to the greenhouse, and allowed to rest for three or four days until the spray had dried. Four of the plants were then taken, and from each, one-half of the foliage was carefully removed, dried, and ignited, and the quantity of copper in the ash was determined. The remaining half of each plant was submitted to the action of rain, artificially produced; the foliage, after drying, was incinerated, and the copper in it determined as in the half which had not been submitted to the action of rain. The artificial rain, being under complete control, was employed in three different degrees of intensity: torrential rain (*pluie d'orage*) for 22 minutes, heavy rain for 6 hours, and light rain for 24 hours—separate sets of four plants each being submitted to each kind of rain. The torrential rain corresponded to a fall of 17 millimetres, or seven-tenths of an inch, in 22 minutes; the heavy rain to a fall of a slightly smaller quantity in 6 hours; and the light rain corresponded to a fall of 10 millimetres, or about four-tenths of one inch in 24 hours. Six different kinds of spraying preparation were submitted to trial; and M. Girard summarizes the results he obtained in two tables, one of which shows the proportion of copper removed from the foliage by the rain, assuming the quantity originally adhering to the foliage to have been 100 parts in each case. This table is as follows:—

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[1] "Bulletin de la Société d'Encouragement pour l'Industrie Nationale," tome vii., p. 156.

Proportion of Copper per cent. removed by Rain.

Spraying Preparation.	Torrential Rain.	Heavy Rain.	Light Rain.
1. Copper sulphate, 2 per cent.; lime, 2 per cent.,	50·9	34·5	13·2
2. Copper sulphate, 2 per cent.; lime, 1 per cent.,	35·3	35·2	16·5
3. Copper sulphate, 2 per cent.; aluminium sulphate, 1 per cent.; lime, 3 per cent.,	32·7	24·5	15·9
4. Copper sulphate, 2 per cent.; soda crystals, 3 per cent.,	19·7	15·9	7·7
5. Copper sulphate, 2 per cent.; lime, 2 per cent.; treacle, 2 per cent.,	11·2	0·0	0·0
6. Basic copper acetate (verdegris), 1·6 per cent.,	17·2	17·3	10·2

As M. Girard points out, it is evident from these results that the copper is removed more by the mechanical action of the rain than by its action as a solvent. Preparation number 5, which is the ordinary Bordeaux mixture, with two per cent. of treacle added, is, according to M. Girard, that which possesses the most marked power of adhering to the leaves of the potato plant. Next to this is the preparation known as Burgundy mixture, prepared by adding a solution of crystallized sodium carbonate, or common washing soda, to a solution of copper sulphate. It might be supposed that the preparation containing the largest proportion of soluble matter, in conjunction with the copper hydroxide, which is the basis of all the preparations, except number 6, would, after drying on the leaves, yield most readily to the action of rain, but it is preparations of this kind which show the least tendency to wash off.

MM. G. M. Guillon and G. Gouirand have published the results of similar experiments on the adhesion of spraying preparations to vine leaves.[1] Their experiments were made both with plates of glass and with vine leaves, and with natural and artificial rain. The precise mode of experimenting is not explained, but it is pointed out that widely different results are obtained with freshly prepared spraying preparations, and with the same mixtures used some time after their preparation. Experiments were made with sixteen different spraying preparations, used immediately after preparation, three hours later, and twenty-four hours after preparation. Comparing the results obtained with those of Girard, I find that both authorities agree in assigning a greater adhesive power to the preparation made with carbonate of soda than to that made with lime; but while Girard found that the lime preparation is removed by rain to about twice the extent of the soda preparation, Guillon and Gouirand found a much smaller difference in favour of the soda preparation. They show that while 64·5 per cent. of the lime preparation is removed by rain, only 42·7 per cent. of the soda preparation is so removed. The latter authorities found that the addition of treacle to the lime preparation greatly reduced its adhesive power—a result totally different from that obtained by Girard. In the case of verdegris, also, they obtained wholly different results. MM. Guillon and Gouirand found that, in some forms, the adhesive properties of this substance are very slight; but, considering that the substances known in France as "*verdet gris*" and "*verdet neutre*" are of somewhat variable composition, the difference in the results obtained are not to be wondered at. The most interesting feature in the results of Guillon and Gouirand is the effect of keeping on various spraying preparations. They show that, while preparations made with lime and with verdegris undergo scarcely any change if kept for some time, those made with sodium carbonate deteriorated rapidly. A preparation containing 2 per cent. of copper sulphate and 4 per cent. of sodium carbonate washed off to the extent of 42·7 per cent. when freshly prepared, whereas, twenty-four hours after its preparation, it washed off to the extent of 93·8 per cent.

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[1] "Comptes Rendus de l'Academie des Sciences," tome 127, pp. 254 and 423; also Revue de Viticulture, tome x. p. 631.

One of the advantages which may be claimed for Burgundy mixture, in comparison with Bordeaux mixture, is the ease with which it may be prepared in small quantities as required. The two ingredients, a solution of copper sulphate, and a solution of sodium carbonate, may be prepared separately and kept any length of time, being mixed only as required. Notwithstanding this fact, it may be found convenient to prepare the mixture in larger quantities than can be used immediately; I therefore thought it desirable to repeat the experiments of Guillon and Gouirand with this mixture. After several trials I abandoned the attempt to use the leaves of plants owing to the difficulty of securing trustworthy quantitative results, and resorted to glass plates, which have the great advantage of giving precise and definite results. A number of glass plates, carefully washed and dried, were sprayed with Burgundy mixture immediately after preparation. The plates were then allowed to dry, and the next day they were submitted to the action of artificial rain equivalent to a fall of $\frac{1}{10}$ inch in five minutes. The washings of the plates were evaporated, and the copper in the concentrated liquid was determined electrolytically. The copper which had remained on the plates was dissolved off with dilute sulphuric acid, and the copper in this liquid was also determined electrolytically. Another set of plates was treated in precisely the same way, except that the spraying preparation had been kept standing in an open vessel, at a temperature of 60° F., for twenty-four hours. The results were as follows:—

	Copper removed by Rain.
Fresh Burgundy mixture, ...	18·52 per cent.
Burgundy mixture, 24 hours old, . . .	13·70 ,,

I have made a number of other experiments, in which the proportion of sodium carbonate was varied, but I have failed to observe any marked difference in the adhesive qualities of the mixture as a result of keeping.

During the past summer I conducted a series of experiments on the adhesive properties of certain preparations. My experiments were carried out on potato plants of the "Beauty of Bute" variety, grown in pots in one of the glass-roofed rooms of the Royal Dublin Society's new chemical laboratory. Observations of the kind intended involve a great deal of trouble if trustworthy results are to be obtained. I therefore decided to limit the work to spraying preparations in actual use in this country, with the exception of one preparation containing potash. The following preparations were employed:—

A. Bordeaux mixture prepared by precipitating a solution of copper sulphate with milk of lime, the lime being added in sufficient quantity to produce a slightly alkaline reaction.

B. Burgundy mixture prepared by precipitating a solution of copper sulphate with ordinary crystallized sodium carbonate (soda crystals), in the proportion of three parts of the latter to two of the former.

C. A preparation in which the copper was precipitated as hydroxide by adding a solution of potassium hydroxide, until the reaction was slightly alkaline.

D. One of the ready-made spraying powders in extensive use, the active constituent of which is copper hydroxide, in the form of a green powder.

In each case the spraying preparation used contained exactly the same quantity of copper in a given volume, viz., copper equivalent to two parts of copper sulphate in 100 parts of water.

Five pots of potato plants were sprayed with the preparation A, another five pots with B, and so on. Care was taken to use as nearly as possible the same quantity of spraying preparation with each set of plants, and to employ a spray of the same character. The plants were then allowed to dry, when their appearance was noted. The deposit produced by A was evenly diffused, and of a light green colour. The B deposit was of a bluish tint and not so evenly diffused as A, the drops of spray having a greater tendency to run together and collect at the tips of the leaves. The C deposit was so nearly the colour of the leaves that the plants scarcely differed in appearance from those which had not been sprayed. The deposit produced by D was unevenly diffused, and adhered for the most part to the edges of the leaves.

The plants were now submitted to the action of artificial rain, the same quantity of water being used with each set, and in such a manner that the drippings of the leaves were collected. The artificial rain was produced by the Muratori Sprayer previously used for spraying the plants, and corresponded to a fall of a quarter of an inch in one minute. The drops, being very minute, produce a mechanical action much less violent than would be produced by an equally heavy natural rain-fall. The quantity of copper removed from the leaves by this treatment was then determined. Ten days later the operation was repeated, so that each set of plants may be regarded as having been submitted to two showers of rain at an interval of ten days. Finally all the leaves and stalks of the plants were removed, dried, and ignited, and the quantity of copper in the ash was determined. The total quantity of copper originally deposited on the leaves of each set of plants is ascertained by adding the copper in the rain washings to that found on the dried leaves and stalks. To facilitate comparison I have calculated the quantity of copper removed by each shower of rain for every 100 parts of copper in the original deposit. The quantities are shown in the following table:—

Copper removed from Potato leaves by Rain.

Spraying Preparation.	First Shower. Per cent.	Second Shower. Per cent.	Total washed off. Per cent.
A,	2·92	3·65	6·57
B,	trace.	0·81	0·81
C,	3·15	2·79	5·94
D,	46·60	5·97	52·57

These results confirm the results obtained by Girard as to the adhesive power of the soda preparation (Burgundy mixture) being greater than that of the lime preparation (Bordeaux mixture); but my determinations show a much greater difference in favour of the soda preparation than Girard obtained. It will be observed that the potash preparation shows an adhesive power almost identical with that of the lime preparation. The most remarkable fact brought out by the experiments is the singularly low adhesive power of the ready-made spraying preparation. No less than 46·6 per cent. of the deposit was removed from the leaves by the first shower, being about sixteen times as much as was removed in the case of the properly-prepared lime preparation. These results I have confirmed by repeated experiments with leaves and with plates of glass. I have not given the name under which this preparation is sold, because it indicates the name of the maker of the powder. It is, however, only one of several powders in common use, identical in character, and sold under various names as remedies for potato blight.

The results may be summarised as follows:—

1. The tendency to subsidence is about equal in lime and soda mixtures, and is so small as to be negligible. In the case of mixtures made with dry powders containing copper hydroxide the subsidence is very great, and takes place rapidly.

2. The deposit produced on leaves by soda mixture possesses a greater adhesive power, or power of resistance to the action of rain, than that produced by lime mixtures. The adhesive power of the deposit produced by mixtures made from dry powders containing copper hydroxide is extremely low.

It follows from these results that dry copper hydroxide powders must be set aside as the most unsuitable of the preparations in use in Ireland. The choice rests between mixtures prepared by adding either milk of lime or a solution of sodium carbonate to a solution of copper sulphate. If one could be quite sure that copper alone is the active constituent of the deposit produced by these mixtures, I should not hesitate to recommend the use of the soda preparation, on account of its superior adhesive properties, the great ease with which it can be prepared, in a condition of perfect freedom from gritty matter, and in a state eminently adapted for use with spraying machines. It is, however, by no means certain that the lime in Bordeaux mixture does not perform a useful function, and for this reason I am of opinion that the lime mixture is the safest to use in our present condition of uncertainty on this point. Sometimes good unslaked lime is not easily obtained just when it is required, and unfortunately it cannot conveniently be kept for any length of time. Under such circumstances the soda preparation should be used.

It is, perhaps, scarcely necessary to point out that, whatever preparation is used, a spraying operation has little chance of success unless the deposit actually dries upon the leaves. If a well-made lime or soda preparation is uniformly distributed in a fine spray, and allowed to dry completely on the surface of the leaves, one need not be concerned about the subsequent effects of rain.

I have to express my indebtedness to Mr. Thomas Porter and Professor Thomas Johnson, D.Sc., for valuable information, of which I took advantage in this investigation.

IV.

EXPERIMENTS IN THE PREVENTION OF "SMUT" (*USTILAGO AVENÆ*, JENS.) IN OATS. By T. JOHNSON, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, and Keeper of the Botanical Collections, Science and Art Museum, Dublin.

[Read NOVEMBER 20; Received for Publication, NOVEMBER 28, 1901;
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DURING a visit I paid in the late summer of 1899 to Connemara, on behalf of the Congested Districts Board for Ireland, to investigate the cause of the disease of the potato-plant called "yellow blight," I had the opportunity of visiting Inishbofin, where I was struck by the marked prevalence of "smut" in the oat crops of the islanders. On inquiry I found that the seed sown was that saved from year to year from their own crops, and that it was not treated in any way to prevent the recurrence of the "smut." On returning to Dublin I discussed the possibility of carrying out experiments to test the value of various fungicides with Mr. T. S. Porter, who was then Agricultural Superintendent of the Irish Land Commission, and through him the experiments I am about to describe were undertaken by the Congested Districts Board. A quantity of smutty oats of the 1899 crop was secured, and treated by me with different fungicides. Pot experiments were made with the help of Mr. F. W. Moore, Keeper of the Royal Botanic Gardens, Glasnevin, and, in addition to a small plot at the Gardens, plots were started in the West of Ireland on Bofin itself, and also near Clifden. Without going into details as to the results of the experiments in 1900, it will be sufficient to mention that the results were such as to justify the continuation of the experiment.

So serious is the injury caused by smut in oats that a few years ago it was estimated that the annual loss in the United States alone was between three and four million pounds.

That oats form an important crop in Ireland is evident from the statistics recently published by the Irish Department of Agriculture, showing that, in 1900, Ireland grew 1,105,050 acres, yielding 17,511,579 cwts. of grain. There are no statistics as to the loss caused by oat smut in Ireland. In the West 10 to 50 per cent. of the crop is not uncommonly lost by its presence.

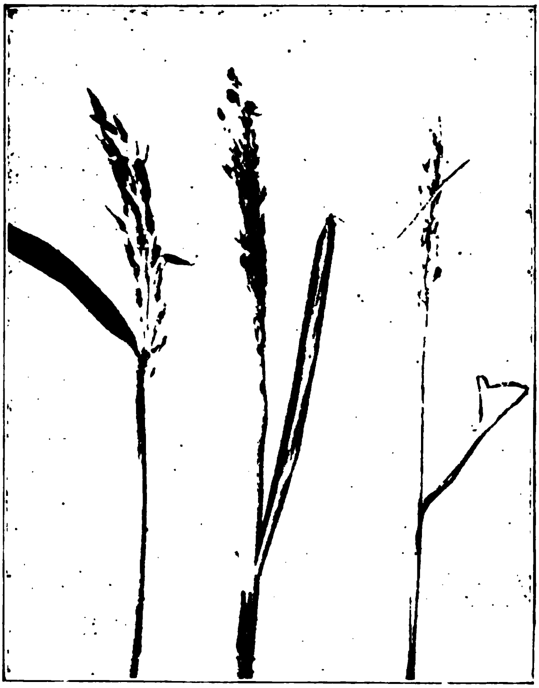

Fig. 1.—Three heads of Oats, showing in an increasing degree, from left to right, the destruction of the grain by the Smut disease.

It is as the infected oat plant passes from flower to ear that the grains and chaff are seen to become black, and the grain, more and more, a dark powdery mass of loose smut-spores, which, by wind and rain, are scattered so that in the end nothing but the bare stump of the ear is left. It need hardly be mentioned that grains in which the normal store of food materials in the seed has been replaced by the smut-spores are, when not, as is occasionally the case, completely dissipated, useless both as food for man or beast and for sowing purposes. The illustration (fig. 1) shows what "smut" is, and the way in which oats are injured when attacked by it. After considerable investigation, it was at last discovered by Hoffmann that the oat plant is liable to attack by the "smut" fungus in its early, seedling stage only, just after the grain has begun to sprout, and when its surface tissues are most delicate and easily damaged. It was discovered that, if the seedling can be safely carried beyond this stage, it is itself practically free from any danger of attack by the "smut" fungus. This scientific fact is the basis of all the different modes of disinfection or treatment of oat grain with fungicides.

From the illustration already seen, it will be evident that, if in any grain saved for seed, there are a few ears of smutted grain, these few ears will be enough to contaminate the whole stock, scattering the smut-spores throughout it, and causing otherwise healthy grain to have on its surface some smut-spores. The object of the treatment with a fungicide is to kill these adherent spores, and to prevent them from sprouting. Should they sprout, there is a great probability that they will indirectly, through branching threads or hyphæ, penetrate the delicate surface of the young stem or leaves of the oat plantlet.

The oat plant will thus become infected, and its grain doomed, in all likelihood, to ultimate destruction. It is a peculiar feature in the life-history of the "smut" fungus that it lives hidden in the oat plant, growing up with and fed by it, and only revealing its presence, when the oat flower should turn to grain, by the black powdery mass which takes the place of the grain. A very important discovery was this, that though the "smut" fungus is a parasite, obtaining its food supply at the destructive expense of the *living* oat plant, the smut-spores are *saprophytic*, that is, they sprout and feed at first on dead animal or plant matter, such as is the ordinary manure put into the ground.

It is this adaptive power of the spores which vitiates to a certain extent the success attained by the treatment of oat grains for sowing purposes, with fungicides. The spores of the "smut," like those of many other fungus-pests, retain their power of sprouting for several years (in one case after being kept dry for seven and a half years); hence if the grain, freed from smut-spores by treatment, is sown in ground containing germinable smut-spores left from a recent smutted crop, there is danger that, in spite of the treatment, there will be smut in the new crop. At least three years should, if possible, elapse before oats appear again in the rotation.

The dark, thick-walled, round resting-spore does not, except very rarely, form, on sprouting, a thread which can directly infect the oat plantlet. It rests from the autumn through the winter until the following spring, and then, under moist nutritive conditions, germinates and forms a short-jointed thread on which more delicate secondary spores or sporidia arise. By the use of a sterilised decoction of manure, Brefeld kept alive a culture for ten months, and got at least 1000 generations of these sporidia from one original resting-spore. He thus established the fact that the secondary spores or sporidia can go on being formed, and can themselves bud in a yeast-like manner, under such favourable conditions as the manured ground in the spring presents. In this way the possibilities of disease in the crop are enormously increased, since it is these secondary spores or sporidia or their derivatives which sprout and form the branching threads which infect the oat seedling and set up the smut disease. Frank added to the information as to the circumstances most suited to their active sprouting and multiplication by the discovery that a sugary medium, such as a germinating grain provides, distinctly favours the formation and sprouting of the sporidia. Moisture, without which neither the resting-spores nor their secondary spores can sprout, also favours the fungus, and helps to spread the disease, and thus to account for the prevalence of smut in the West of Ireland. Dry warm soil, at a temperature of 60° F. is favourable to the oat, but not to the smut spore, germination.

In one of the selected untreated test plots of this year, one of the farmers found his crop so smutty that he did not attempt to gather it, but turned his cows on to it. The employment of the manure from such animals would inevitably put the "smut" spores into the ground under the conditions most favourable for sprouting, and attacking otherwise healthy oats.

EXPERIMENTS IN 1901.

For the experiments in 1901 the Congested Districts Board obtained from Co. Donegal thirty stones of oats, which I first made sure were really smutty. This quantity was divided into lots and treated as follows:—

No.	Fungicide.	Strength of Solution.	Time of Immersion.
1	"Sar" or Sodium Sulphide (6*d*.–9*d*. per pint).	0·5 per cent., *i.e.* 1½ pints of Sar in 50 gallons of water.	24 hours.
2	Potassium Sulphide (8*d*. per lb.).	0·5 per cent., *i.e.* 1½ lbs. of Potassium Sulphide in 25 gallons of water.	24 hours.
3	Copper Sulphate (4*d*. per lb.).	0·5 per cent., *i.e.* 1 lb. of Copper Sulphate in 22 gallons of water.	12–16 hours.
4*a*	Formalin (2*s*. 6*d*. per lb.).	0·2 per cent., *i.e.* 1 lb. of Formalin (⅞ pint) in 50–60 gallons of water.	2 hours.
4*b*	Formalin for 2 hours followed by Ammonia.	0·2 per cent., *i.e.* 1 oz. Ammonia in 4¾ gallons of water.	15 minutes.
5	Hot water.	132° F.	10 minutes.
6[1]	—	—	—

Sar Solution.—The first fungicide mentioned, "Sar," is one which has been introduced, and is strongly recommended by the U. S. A. Department of Agriculture in the "Farmer's Bulletin," No. 75, 1898 ("The Grain Smuts," by Walter T. Swingle), from which (page 15) the following particulars are taken:—

"This fungicide, here announced for the first time, is composed principally of sodium sulphide instead of potassium sulphide. It is much cheaper than the potassium sulphide, is more convenient to keep and to use, and has proved equally as effective. However, it has not been tested extensively for smuts, but will doubtlessly prove effective. It is prepared as follows:—Place 15 pounds of flowers of sulphur in a barrel, mix thoroughly with it one-half pound of finely powdered resin, and stir well

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[1] Control not treated.

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with three quarts of water, which should make a thick paste. The paste must not be thin and watery, nor so dry as to crumble to powder when stirred. Then add 10 pounds of powdered caustic soda and stir well. After from three to fifteen minutes the mass turns a reddish brown, and boils violently, and must be stirred well, preferably with a broad paddle, to prevent it from running over. After it has ceased boiling, add slowly about two gallons of water (hot if possible, but cold will do), and then carefully pour off into another vessel marked to hold six gallons, and add hot water till the six-gallon mark is reached. This gives a stock solution, which must be kept in tightly corked jugs, or in closed barrels or kegs, since it spoils if it comes into contact with the air. It is also decomposed if it touches metals. Of this stock solution use 1½ pints to 50 gallons of water, soaking the seed twenty-four hours, or in 1 gallon to 50 soaking for two hours. In order to give this fungicide a short name, the word *Sar* has been adopted, being coined from the first letter in each of the words sulphur, alkali, and resin."

Potassium Sulphide.—The potassium sulphide (the fused kind known as "liver of sulphur") should be put in lumps into the water at the rate of 1¼ pounds of potassium sulphide to 25 gallons of water. This gives a weak (0·5 per cent.) solution, in which the oats—three bushels—are soaked for twenty-four hours. The solution, of a clear, yellowish-brown colour, is soon ready, as the sulphide dissolves quickly. Like the Sar, it should be kept from contact with metal and also from the air. A wooden vessel should be used, and care should be taken by stirring, &c., to see that all the grains are thoroughly wetted. If the 2 per cent. solution is used—8 pounds in 40–50 gallons of water—the soaking should last for two hours only. The grains in this case dry more quickly. My experience is that it is as effective as the longer immersion in the weak solution, and, like it, does not lessen the germinating power of the oats.

Copper Sulphate.—The treatment—12–16 hours soaking in a 0·5 per cent. solution of copper sulphate, made by dissolving one pound of powdered copper sulphate in 22 gallons of water—was too drastic, and my experience confirms that of the Americans, who do not recommend the use of copper sulphate as a fungicide for loose smut in oats. The seeds, after the soaking, showed, in my case, a very low germination, and, as a rule the roots failed to sprout, though the shoot did, a result subsequently abundantly confirmed in all the field plots. If copper sulphate is used, the oats should not be soaked in it, but sprayed only, and afterwards treated with lime.

Accounts of experiments with copper sulphate and "Bordeaux mixture" are somewhat contradictory, but, on the whole, the other fungicides can be used with greater certainty of success.

Formalin.—This powerful fungicide was used in weak solution—0·2 per cent.—made by mixing one pound of commercial formol (a 40 per cent. solution of formaldehyde gas) with 50 gallons of water, the soaking lasting two hours.

As formalin had been found by other observers to tend to lessen the germinating power of the oat grain, some of the grain treated with it was afterwards treated, as recommended by David, with a 0·2 per cent. solution of ammonia for fifteen minutes. The effect is shown in the table, where 4*a* is the result without, 4*b* with, after-treatment with ammonia. The germination, as tested by the incubator, gave 99 per cent. for formalin treatment alone, 96 per cent. for formalin followed by ammonia.

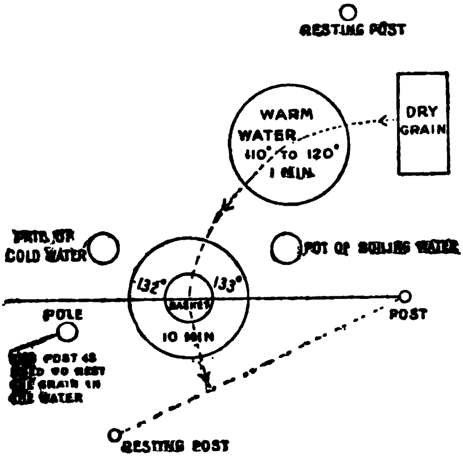


FIG. 2.—Method of killing Oat-Smut spores by soaking Oats for ten minutes in water at 132° F.

Hot Water.—Swingle gives in the "Farmer's Bulletin," already mentioned, a detailed account of the mode of treating smutted oats with hot water, first successfully tried by Jensen. The diagram, an adaptation of his, taken from the "Annual Report of the Department of Agriculture of Ontario," shows the arrangements necessary.

Treatment with hot water is very cheap and effective, but requires absolute accuracy. If the temperature is a few degrees too high or the steeping is continued too long, the oats as well as the smut-spores will be killed; if too low the heat will not kill the smut-spores adherent to the grain.

For simplicity of procedure it cannot be compared with either the *Sar* or *Potassium Sulphide* method, and on this account cannot, unfortunately, be recommended for general adoption in the West of Ireland.

In order to exclude the personal equation as much as possible the oats were sent out simply numbered, and the growers had no information as to the treatment the grain had passed through, an arrangement which adds interest to the views expressed by them. The sub-plots were 10 to 20 perches in extent.

Mr. R. Y. Smith, the Board's Instructor in the Clifden district, Connemara, says of the sub-plots there, at the end of August:—"No. 6—(*i.e.* the *untreated* grain)—is very nearly half smut, and a poor crop." It is in the same smutty condition as the farmer's own untreated plot close by—double confirmation, unknown to Mr. Smith at the time, of the valuable effects of steeping. Mr. D. S. Simpson, in charge of the Tourmakeady district, Co. Mayo, found that No. 6 sub-plot—also the untreated one—"had more smut than all the others put together," No. 5 sub-plot, treated with hot water, being free from smut. Mr. P. Taylor, in the Glenties district, Co. Donegal, writing early in September, found very little smut in any of the treated plots, but described No. 6 (the untreated) as "very bad with smut," like the neighbouring plot of the farmer's untreated oats.

The following tables give the results of weighing the grain and straw yielded at the three centres, and show clearly that the treated grain yields distinctly better than the untreated.

GRAIN.

Rate of yield per acre.					Standard.
No.	Clifden (Co. Galway).	Tourmakeady (Co. Mayo).	Ardara (Co. Donegal).	Average.	Smut-free Crop.
1	1650	1370	2240	1750	1600 to 3200 lbs. (40 to 80 bush.)
2	1800	1850	**3168**	2270	
3	1380	1250	1872	1500	
4	1550 (*b*)	1240 (*a*)	2240 (*a*)	1676	
5	**1920**	**2000**	2080	2000	
6	1120	1330	2080	1510	

STRAW.

Rate of yield per acre.					Standard.
No.	Clifden (Co. Galway).	Tourmakeady (Co. Mayo).	Ardara (Co. Donegal).	Average.	Smut-free Crop.
1	3840	1720	4432	3330	2800 to 5040 lbs. (25 to 45 cwt.)
2	4160	2090	**5760**	4000	
3	3820	1840	4256	3305	
4	3680 (*b*)	1610 (*a*)	4432 (*a*)	3240	
5	**4240**	**2250**	4230	3573	
6	3040	2150	4430	3206	

In inspecting these tables, it should be remembered that the grain in Nos. 1, 2, 3, 4, 5 was comparatively free from smut, that of No. 6 full of it, and that in the same way the straw was of excellent quality in the treated plots, but very inferior in the untreated, and as such straw has, clinging to it, smut-spores, it should not be allowed to find its way into the manure heap without treatment.

In addition, small plots in duplicate, in which the five kinds of treatment mentioned in the table were given, as well as duplicate plots treated with strong Sar and strong potassium sulphide—2 per cent. in each case—were undertaken by Mr. F. W. Moore in the Royal Botanic Gardens, Glasnevin, and inspected by me from time to time. They abundantly showed the beneficial effects of a fungicide, such as Sar or potassium sulphide, weak or strong, formalin or hot water, but not of copper sulphate.

REPORT ON THE EXPERIMENTS IN THE USE OF SAR.

The experiments in 1900 were so satisfactory as to justify the Congested Districts Board in having made up and distributed to farmers in the West of Ireland half-pint jars of Sar, for trial in the prevention of smut in 1901. There were in all, in the counties Galway, Mayo, and Donegal, fifty-five plots, each plot having one sub-plot of steeped and another of unsteeped oats, care being taken that the oats tried were obtained from a smutted crop of 1900. The following is an abstract of the reports of the Instructors of the Congested Districts Board in the various districts where the Sar was under trial:—

Mr. W. Munro, Carrigart, Co. Donegal, reports that Sar proved a great preventive of smut, and that it appeared to prevent injury from grub too. Of the nine plots there was, in every case, less smut in the steeped oats than in the unsteeped, and in some steeped plots there was no smut at all.

Mr. P. Nolan, Glenties, Co. Donegal, reports that there was no trace of "smut" in the eight steeped sub-plots, and that the steeped oats sprouted a few days earlier than the unsteeped.

Mr. D. S. Simpson, Tourmakeady, Co. Mayo, states that Sar proved a great success in preventing smut, and that it seems to have the same effect on oats as "Bordeaux Mixture" has on potatoes—it not only kills the germs of the disease but strengthens the plants as if manured. This observation is in keeping with the results obtained in the United States, where it was found that the treatment of oats with hot water or potassium sulphide increases the yield beyond that due simply to replacing the smutted oats by healthy ones, so much so, that it is considered it pays to steep oats even if the crop only contains 1 to 2 per cent. of "smut." Mr.

Simpson finds that the steeped oats sprouted about a week earlier than the unsteeped, and recommends, as do the other Instructors, that the oats should be sown, after a few hours' drying, the same day as that on which they are soaked. In one plot on the 15th August, he found the steeped oats practically free from smut, the unsteeped so smutty as to make the plot worthless. Of another plot he writes: "This is one of the best experiments I ever saw; there is no trace of smut in the steeped oats; in the unsteeped there is over 50 per cent. of smutted heads; the plot is so smutty as to be useless." Of another plot, he writes: "The people are very much taken with it: there is one head in 1000 smutty in the steeped, but 40 per cent. smutty in the unsteeped."

Mr. R. Y. Smith, Clifden, Co. Galway, writes that the oats treated with Sar are practically free from smut. Those soaked in a solution used twice are not so good and have more smutty heads, but not so many as the unsteeped. He thinks it is better not to use the same solution twice. Of one part of his district, he writes that the steeped oats showed better straw and grain, and though the steeped showed 10 per cent. of smut, the unsteeped had 50 per cent.

Mr. P. Taylor, Glenties, Co. Donegal, who had twelve plots under trial, reports that the steeped corn came up and ripened several days earlier than the unsteeped, and that it had better-filled and stronger heads, and was practically free from smut. His plot-holders and their friends agreed that Sar is a sure preventive of smut. Mr. Taylor writes of one plot that the steeped oats showed no smut, but the unsteeped were "nearly all smut and greys, and not worth cutting." It was into this plot that the cows were turned. Of another plot it is stated that in 1900 the holder lost all his oats through smut, but that this year the steeped oats did well and showed a fine head. In another case the holder was so pleased with the trial that he decided to keep all the grain from the steeped oats for seed next year. In another case, it is stated that "the steeped oats did very well; the people are all speaking about it."

In only one district was the result of steeping in Sar unsatisfactory. Mr. Finn, the Board's Instructor in the Westport district, Co. Mayo, reported that smut was plentiful in both the treated and untreated plots. Examination of the plot-sheets shows that the rotation of crops in the districts is simply oats and potatoes. All the plots grew oats in 1899, and, assuming that the oats tried in 1901 were effectively soaked, it seems to indicate that they became smutted after being sown, by the smut-spores left in the ground from the 1899 crop. Such a result emphasises the necessity of not growing oats on the same ground, except after an interval of, at least, three years.

SUMMARY.

1. These experiments abundantly show that smut in oats, which is especially prevalent in the West of Ireland, can be almost, if not entirely, prevented by a cheap and simple treatment of the seed oats.

2. The money saved is, as Swingle states, not only due to replacing the smutted oats by healthy ones but is a saving all through. A smutted crop costs as much to grow as a healthy one, and the smutted plant takes up as much room and food-matter as the good one. Hence the money saved is a direct addition to the profit on the crop.

3. Further, as the excellent work of the Ohio Experimental Station has shown, seed oats made smut-free, if kept from contact with smutty crops or seeds, remain smut-free for several seasons, and one treatment thus lasts for several years. It has been estimated that two men in one day can treat enough oats to sow 20 acres.

The jars of Sar distributed by the Congested Districts Board proved, as the reports indicate, so effective that I would recommend this as a satisfactory mode of treatment. Sar is cheaper, and keeps better than potassium sulphide.

It would not be safe to draw definite conclusions as to the relative value of Sar and potassium sulphide from the three plots, the weight results of which have been given. It would appear from them, however, that Sar is not at any rate more fungicidal than potassium sulphide, and that if this latter compound could be sent out in tins and kept from contact with air until required for use, it would prove as effective if not so cheap as Sar.

The half-pint jar of Sar costs less than 6*d*., and mixed in a wooden vessel with 16–20 gallons of water serves for treating two bushels of oats. As six bushels of oats at most are sown broadcast to the acre, the fungicide required for one acre costs only 1*s*. to 1*s*. 6*d*., and as it may mean a yield of 40–80 bushels per acre instead of half these quantities, the result should induce all growers of oats that are liable to smut, to adopt the treatment.

V.

INJURIOUS INSECTS OBSERVED IN IRELAND DURING THE YEAR 1901. By GEORGE H. CARPENTER, B.Sc., F.E.S., Consulting Entomologist to the Royal Dublin Society.

(Plate I.)

[Read February 19, 1902.]

INSECTS INFESTING DOMESTIC ANIMALS.

The Sheep-Fly.

Lucilia sericata (Meig.).

The parasitic habit of certain fly-maggots in the bodies of live sheep has been well known to practical farmers, working shepherds, and veterinary surgeons for some three centuries at least, while it has been almost neglected by entomological writers. For example, there is hardly a book on sheep-rearing that I have been able to consult but contains some reference to the "fly" and the "maggots," while the voluminous writings of the late Miss Omerod furnish not a single mention of the plague. Probably the nature of the attack, and the means by which the mischief can be prevented or cured, are so well known to practical men that they never need to ask the help of a naturalist. But the subject having come under my notice during the past summer, it seemed that a slight contribution to some exact knowledge of the life-history of the offending insect might be desirable.

In the old work of Ellis (1) published in Dublin in 1749, "approved of and recommended by the Dublin Society," an excellent short account of the sheep-fly is to be found. He writes of the maggots:—

"These sort of vermicular Vermin are the Death of many Sheep and Lambs, for as both these are very subject to breed Maggots, by the blowing of several Sorts of Flies, and by the Heat of their greasy Wools, in hot Weather if they are not carefully looked after by a judicious Shepherd, they may soon be destroyed by these Maggots. . . . These Insects are so prone to multiply, that from their first increase they will kill a Sheep in three Days' Time; . . . a grievous Malady indeed, that ought to be guarded against with the utmost Vigilance, because, Part, or most of a Flock, may, if neglected, be soon destroyed by Maggots. And although this great Evil is but just touched on by ancient Authors, . . . I shall not so pass over the treating on these destructive Vermin, but assure my Reader, that Sheep and Lambs infected by them, will infect others, by lying close in a Fold or elsewhere to one another. Now, the Sheep and Lambs that are most liable to the Breed of Maggots, are those that carry the most and closest wool on their Backs; and the more they are frequently heated by driving them out of their natural Walk, the sooner they come under the Misfortune. . . ."

This quotation shows that the old writer (except for his apparent idea that maggots were bred "by the heat of greasy Wools") had a good working knowledge of the nature of the infestation; and when one consults his "Receipts to Kill Maggots that are on the Bodies of Sheep and Lambs" one realises that little advance has been made in the practical treatment of the subject during the intervening hundred and fifty years. He recognised the part played by the soiled hind-quarters of sheep in attracting the flies, "as, when a careless, indolent Shepherd suffers his Sheep or Lambs, especially those that are loose-dunged, to be daubed behind till the Dung mats, and breeds Maggots." As remedial applications he recommended train-oil, or train-oil mixed with "one sixth Part of Oil of Turpentine," or the strewing of "some powdered dead Lime, . . . a most cleanly Medicine.' And he adds:—

"As Prevention is better than Remedy, it is practised by some *Buckinghamshire* Shepherds to strew some Powder of Brimstone over the Back of the Sheep when they perceive the great Blow Fly begin to be busy. . . . Now to prevent this Damage they part the Wool, and only scatter the Powder, but others do better that rub it in."

One of the "ancient authors" to whom he refers as treating of the fly is Gervase Markham, who died in 1637.

The Ettrick shepherd's reference to the infestation in his work (2) published early last century is of interest, as showing how far astray a gifted writer may go in a simple question of natural history when he indulges in unguarded speculation. He writes:—

"It has been the opinion of many experienced shepherds that they [the maggots] are generated from the seed, or excrement, of the large fly, commonly called the *flesh-fly*. That this will not breed them I dare not assert, it having been so long believed, and there are few old adages that are without some foundation in truth; but that in many, nay, in most instances, I am perfectly certain that they are bred without any interference of the fly. . . . If they be at all the progeny of the fly, sure nature never erred so widely from her usual plan of making children, at least of the same species with their parents. The butterfly, indeed, genders the caterpillar; but the caterpillar, after its various changes, turns a butterfly; the common maggot, however, never turns a fly." (!)

It is of interest and importance to determine how many different kinds of flies are responsible for the sheep-maggots. On this question authorities differ. For example, Price, in his work published in 1809, (3) writes of "the black, white, and greenish fly. The maggots generated from the ova of the first, or black fly, are deemed the most destructive to sheep. This fly is later in making its appearance than either of the others. I have heard it asserted . . . that a considerable difference is observable in the appearance of the maggots, those from the white and green fly being white, while those of the black fly partake of the same colour. I cannot, however, from my own knowledge, vouch for the truth of this assertion, having seen only the green fly, which is very numerous in the marsh at some particular seasons of the year. Sheep that have once been struck with it are more liable than others to be attacked in the following year, as are also those that have a foul skin."

It seems that Price, evidently a careful, practical observer, had first-hand knowledge of only one kind of fly, and that a green one, doubtless a Lucilia.

Although the ravages of the sheep-fly are referred to in the classical work of Kirby and Spence, (4) no information is given as to the species. Those authors write after an account of the sheep bot-fly:—

"The flesh-fly is also a great annoyance to the fleecy tribe, especially in fenny countries, and if constant attention be not paid them, they are soon devoured by its insatiable larvæ. In Lincolnshire, the principal profit of the druggists is derived from the sale of a mercurial ointment used to destroy them."

From a comparison of the various passages in Kirby and Spence where "flesh-flies" are mentioned, it appears that under that term the authors include Sarcophaga and Musca in a wide sense, practically the sub-families Sarcophaginæ and Muscinæ of modern dipterologists.

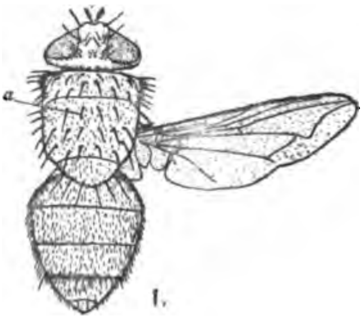
Modern practical writers on sheep and their diseases appear to believe that the sheep-maggots belong to several kinds of flies, referable to two or three distinct genera. For example, Steel (5) mentions "*Musca vomitoria* v. *Sarcophaga carnaria*" (it is hard to believe that he could regard these two very distinct forms as identical); while Wallace (6) refers to *Lucilia cæsar*, *Calliphora vomitoria*, *Pyrellia cadaverina*, and *Sarcophaga carnaria*.

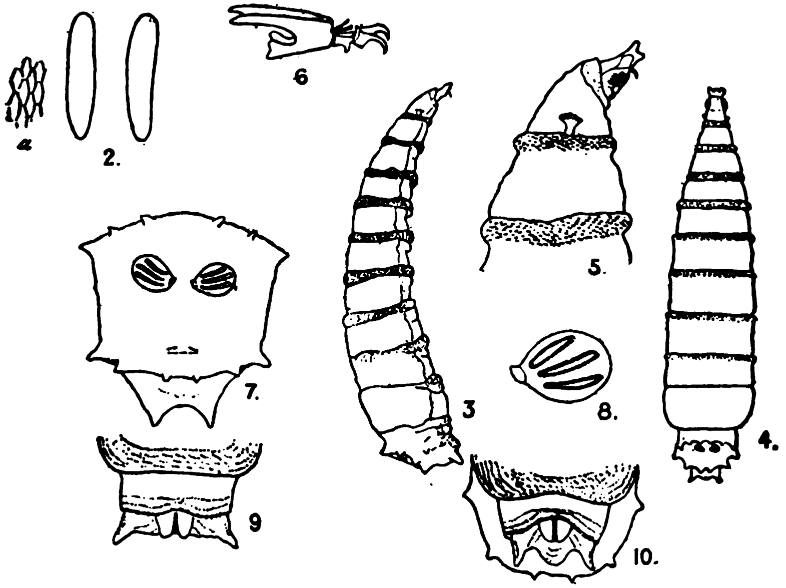
In several of the practical works quoted above, reference is made to the appearance of maggots in sores on the bodies of sheep Now, the occasional breeding in wounds and sores of human and animal subjects, of various flies like species of Sarcophaga and Calliphora, whose maggots normally feed in carrion, is well-known. No doubt the maggots of these flies are occasionally thus present in sheep. But as far as the evidence at present available goes, it seems that the deliberate act of egg-laying on sheep's wool, so that the maggots may feed on or in the live animal, can only be brought home to the bright metallic blue and green flies of the genus Lucilia. There are in the British Museum specimens of *Lucilia sericata* bred from sheep-maggots forwarded by English farmers. The only modern writer who seems to have paid adequate attention to this infestation is J. Ritzema Bos, and in his account (7) he implies that the only "sheep-fly" is *Lucilia sericata* (Meig.). He seems to deny that the common *L. cæsar* (Linn.) attacks live sheep. Mr. J. V. Theobald, however, has kindly informed me that both *L. cæsar* and *L. sericata* act as "sheep-flies" in Great Britain. My friend Mr. R. M. Barrington, knowing my interest in the subject, sent me, in August, eggs and almost full-grown maggots taken from sheep near Bray, Co. Wicklow. The maggots pupated and produced *Lucilia sericata*. I propose, therefore, to give a short account of the systematic position, life-history, and habits of this insect, acknowledging with sincere gratitude my indebtedness to much information most kindly given by Mr. Barrington, as well as to the work of Prof. J. Ritzema Bos, already mentioned.

The genus Lucilia belongs to the great family Muscidæ, in which are included the familiar "house" and "blue-bottle" flies. The flies of this family are characterised by the possession of short, three-segmented feelers, with a bristle borne on the edge of the large third segment, a characteristic wing neuration with the fourth longitudinal nervure bent upwards towards the third at the wing-tip, the presence of scales at the wing-base, and the possession of a distinct proboscis used for sucking liquid food. The sub-family Muscinæ, including Musca (house-fly), Calliphora (blue-bottles), Lucilia, and other genera, is distinguished by the bristle on the feeler being "feathered" throughout its length, owing to the presence of numerous fine sensory hairs. In all Muscidæ the larva is a degraded maggot without head or true legs, moving about by means of spines or processes on its body, and feeding by the help of powerful "mouth-hooks."

The species of Lucilia may, as a rule, be readily distinguished from those of Calliphora (including the common blow-flies or blue-bottles) by the brilliant metallic lustre of their bodies. In the same species the colour may be violet, blue, or green. Further, the space in front of the eyes, below the prominent bristles on top of the head, which is covered with silky hairs in Calliphora, is naked in Lucilia.

Among the various species of the latter genus, *L. sericata* is characterised by the presence of three pairs of central bristles on the median fore-body segment, the front pair of the three evidently present in this species (fig. 1 *a*) being absent in *L. cæsar* and most of the others. *L. sericata* has the bristles on the hinder border of the third abdominal segment comparatively small, and hidden by the long silky hairs. In *L. sylvarum*, which agrees with *L. sericata* in the thoracic bristles, these abdominal ones are long and conspicuous. The palps of *L. sericata* are reddish. (8, 9).





Figs. 1–10.

Fig. 1.—Sheep-fly (*Lucilia sericata*, Meig.); female; × 4. Fig. 2.—Eggs of *L. sericata*; × 10 (*a*, sculpture of surface, highly magnified). Fig. 3.—Maggot of Lucilia from side; × 4. Fig. 4.—Maggot from above; × 4. Fig. 5.—Head-region of maggot, showing fan-like spiracle; × 12. Fig. 6.—Mouth-hooks and pharyngeal sclerites of maggot; × 12. Fig. 7.—Tail end of maggot from above; × 12. Fig. 8.—Right spiracular plate; × 25. Fig. 9.—Tail-end of maggot from beneath, with anal region protruded; × 16. Fig. 10.—The same, with anal region retracted; × 16.

The female Lucilia lays her eggs in clusters of about fifty on the wool of the sheep, attaching them to the hairs half-way between the root and the tip. These eggs are about $\frac{1}{16}$ inch long, and of a creamy-yellow colour. The surface is almost smooth, but high magnification shows delicate ridges forming polygonal areas (fig. 2). According to Dr. J. R. Bos (7) a single female

Lucilia lays as many as five hundred eggs. In Holland these flies begin to trouble the sheep in early spring; but Mr. Barrington tells me that in Ireland they rarely appear before June, and are most plentiful during July and August. The sheep most often chosen by the fly for egg-laying are those whose hind-quarters are soiled; hence animals suffering from "scour" are especially liable to attack. But oily fat as well as excrement attracts the fly; for Mr. Barrington tells me that the insect "is more frequent on greasy-skinned fat sheep, and certainly appears to prefer the Shropshire breed, with its close fleece, to the Roscommon or mountain ewe." Lambs and young sheep are more subject to attack than old ones, and lame or sick sheep than healthy ones. The fly seems more troublesome in rich lowland pastures than in breezy upland grazings.

The young maggots are hatched from the egg in twenty-four hours, or less, and grow to their full size in about fourteen days. The fully-grown maggot (fig. 3–10) is of the form usual in the family *Muscidæ*, and resembles that of the common blow-fly or blue-bottle (*Calliphora erythrocephala*) rather closely. In the Lucilia larva, however, the small, fan-like spiracle (fig. 5) on the prothorax has ten prominences only, instead of the thirteen present in the corresponding organ of the Calliphora maggot.

An examination of the hinder end of the Lucilia larva shows that, like that of Calliphora, there is a large flat area, surrounded by eight small and four large tubercles, in the midst of which the two spiracular plates, each with three slit-like openings, are conspicuous (figs. 4, 7, 8). But the short "anal feet" (figs. 9, 10) in Lucilia are less prominent than in Calliphora, and show no trace of segmentation. The form of the mouth-hooks in the Lucilia larva (fig. 6) and of the pharyngeal sclerites articulated with them differ markedly in several details from those of the Calliphora larva as figured by Lowne (10).

By means of their mouth-hooks the maggots dig their way into the sheep's skin, and the resulting irritation is shown by a constant wagging of the tail, and by scratching and biting at the itching part. Dr. Bos writes: "A sheep whose skin is attacked by fly-maggots usually has them first of all only at the root of the tail, later often on the crupper and loins, now and then even on the flanks, the belly, and the chest. The wool on the afflicted part becomes discoloured, and the hairs matted together, the skin discharging a serous, evil-smelling fluid, which causes this change in the appearance of the wool. The hide, through the irritation of the maggots, some creeping over the upper surface, and some burrowing, becomes very hot, blood-red, and swollen." In bad cases "the maggot-sickness spreads constantly not only over the surface of the skin but even deeper, first to the connective tissues, and later to the muscles. The living flesh is tunnelled and devoured by the parasites."

After describing the inflammation of the skin and the injury to the wool induced by the maggots, Dr. Bos states:—"In most cases the maggot-sickness is not fatal to sheep, but it becomes so when the parasites eat deeply into the flesh." But Mr. Barrington's opinion is, that a sheep will die if the maggots are very numerous, even if they do not pierce the skin.

As previously stated, the remedies for this infestation are well known to practical men. Constant watchfulness on the part of the shepherd, strict cleanliness of the sheep's wool, the quick detection and isolation of infested sheep, and the destruction of the maggots by some oily application, are evident safeguards. Oil of turpentine is recommended by Dr. Bos despite the fact that it irritates the sheep's sore skin. It is the usual experience that ordinary "dips" are not strong enough to kill the maggots, though they may prevent egg-laying by the fly. The old-time use of sulphur for this purpose has already been mentioned, and carbolic acid solution would probably be effectual also. Every farmer who knows the life-history of the fly should impress on his dependents the necessity of killing at once badly infested sheep, and burning the carcase. Every neglected "case" means the possibility of scores or hundreds more if the maggots are allowed to complete their transformation.

One of the most interesting points about this infestation is its apparent restricted distribution. It seems to be essentially a British and Irish plague. On the European continent it seems to have been recognised only in France and Holland (11); and the epidemic in the latter country, that formed the material for Bos' researches, was believed by many to have been due to sheep imported from England. There is no reference known to me in American entomological literature to such an infestation.

The fact that the female Lucilia is readily attracted to the soiled hind-quarters of sheep has led to the conclusion that dung was the original food-material of the maggots. But Karsch (12) gives good reasons for believing that the insect is a true "flesh-fly," and its maggots carrion-feeders. He reared the insects in Berlin in decaying flesh, and the references given by Brauer (13) to the maggot of *L. sericata* mention its feeding-place as dead birds.

It seems, then, that over a limited area one or two kinds of flesh-fly have forsaken the usual habit of their family, so that the maggots have become parasites instead of scavengers. There can be no doubt that this change of habit has been induced by the domestication of sheep by man. We have taken an originally alpine race of animals, crowded them on the plains, and by artificial selection increased the qualities—such as fat and thick wool—that tend to attract the fly. Moreover, the comradeship of sheep with men has rendered them more helpless than most of our domestic animals. To do all we can to save the flocks from this horrible scourge is therefore our duty as well as to our interest.

CABBAGE AND TURNIP INSECTS.

The Turnip "Fly."

Phyllotreta nemorum (Linn.) and other species.

As usual the turnip beetles or "fly" have been noticed in several localities. Towards the end of May Mr. D. O'C. Donelan sent me leaves of turnips and cabbages from Ennis, county Clare, that were badly injured by these insects. In my previous Reports I have called attention to the recent practice of spraying infested crops with a 1 per cent. solution of potato-spraying mixture (copper sulphate and lime). The success attending this treatment was first made known by Mr. T. Smith, of Ballymote, county Sligo, in the *Farmer's Gazette* for 29th July, 1899. The editor of that journal published on July 20th, 1901, some interesting notes received from correspondents on the effects of such spraying. Both

Mr. S. B. Murray of Triermore, Fordstown, near Kells, and Mr. E. Lynan, of Gortnamona, Ballinasloe, report most favourably on the result. The former stated that his "crop looked like being a total failure," but that after spraying he had "a very fair crop," while the latter "found Lawes' anti-blight mixture as recommended to completely kill the turnip-fly." On the other hand, a correspondent at Lucan, county Dublin, reported that the treatment "was not a success." At an unnamed locality in the south of Ireland, the only result of the spraying was to cause serious damage to the crop. "I sprayed my turnips this year," the farmer wrote, "with 1 per cent. anti-blight solution, and it seemed to burn the whole of them almost. I have not half a crop in the plot I sprayed, though the fly had very little damage done . . . and one row of plants that were not up strong died out altogether." In this last mentioned case it may reasonably be supposed that by some oversight a too strong solution was applied. It is important to note that the safe strength to use is half that appropriate for potato-spraying.

The Turnip Aphid.

Rhopalosiphum dianthi (Schr.).

Specimens of turnip leaves infested with this well-known Aphid were sent to me in June by Capt. R. H. Fowler of Rahinstown, Enfield, county Meath. No remedy for this pest seems more satisfactory than spraying with paraffin emulsion.

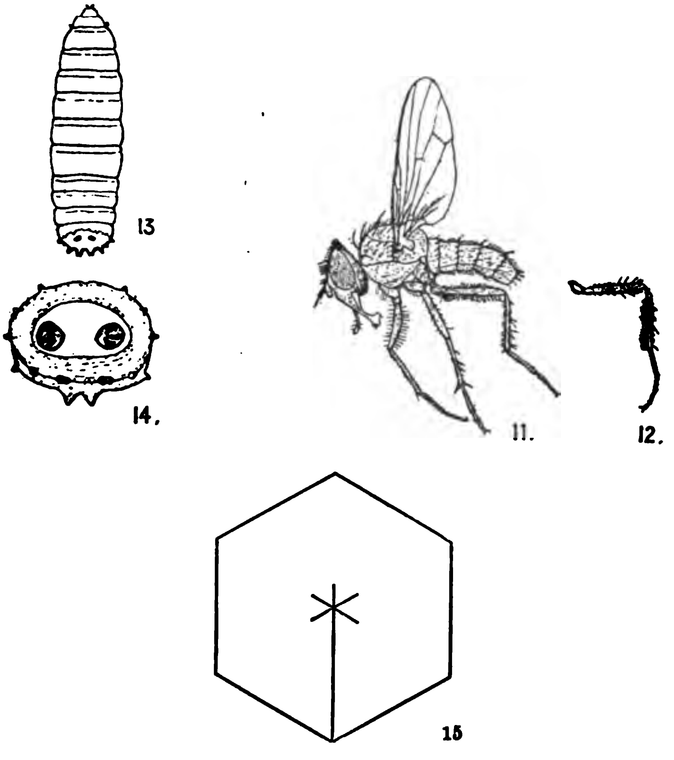
The Cabbage Flies.

Phorbia brassicæ (Bouché) and *P. fusciceps* (Zett.).

The prevalence of the root-eating maggots of these flies among cabbage and turnip crops has been one of the most marked features of the year. In mid-winter (early January) Mr. Duncan, Agricultural Lecturer for county Tyrone, sent specimens of infested turnips to the Department of Agriculture, and similar ravages were observed in county Down. It was evident therefore that the mildness of the winter 1900–1 enabled these insects to continue feeding throughout the greater part of the year. As the season advanced more was heard of their ravages. In May, Mr. D. O'C. Donelan sent me badly injured cabbage roots from Ennis, county Clare. In that locality he wrote: "The turnip crop has been so badly attacked that it has been to a large extent abandoned, and field cabbage adopted instead. This now is beginning to suffer."

In June Mr. T. Alexander Rudd noticed cabbage-crops near Enniscorthy to be badly attacked by the root-maggots, and kindly forwarded specimens to me, stating that fully 10 per cent. of the crop was affected. In July my friend Mr. R. M. Barrington, of Fassaroe, Bray, sent me turnip roots badly eaten by the maggots; while Mr. T. M. Carew, of Kinnegad, county Westmeath, forwarded cabbage roots similarly attacked. These maggots from Fassaroe and Kinnegad, received July 20th–27th, pupated very soon, and the flies emerged in the Museum breeding cages from August 8th–10th. In all the localities from which maggots were received the destructive species proved to be *Phorbia brassicæ* (Bouché), (= *P. floccosa*, Meig.), but among the flies bred from the Fassaroe maggots, a smaller kind, *P. fusciceps* (Zett.) (= *cilicrura*, Rond.), was present also. The genus Phorbia, to which these flies belong, is characterized by the parallel-sided hind-body of the male. Formerly they were included in Anthomyia. *P. brassicæ* is a larger insect than *P. fusciceps;* and the male is readily distinguished by the presence of a dense tuft of hair beneath the base of each hind thigh (fig. 11). The male of *P. fusciceps* has a regular comb-like row of bristles along the inner edge of each hind shin (fig. 12). The most characteristic feature of the maggot of *P. brassicæ* is the bifid form of the two hinder tubercles surrounding the spiracular area (figs. 13, 14).

The photograph (Plate I., A) of one of the injured cabbage-roots shows how the maggots of these flies eat away the surface-tissue of the root, and finally burrow deeply into the substance. The eggs as laid by the female fly on the roots can be seen above. For the purpose of egg-laying, she makes her way through the loose soil. In his exhaustive memoir of these insects Professor M. V. Slingerland (14) recommends the use of tarred cardboard discs (fig. 15) so applied to the plants that the radiating slits in the centre fit tightly around the stem. There can be no doubt after Slingerland's experiments that these discs are effective in preventing the attacks of the fly, and as it has been doubted by Irish farmers whether their use would prove profitable on a large scale, it may be well to draw attention to Slingerland's statement that, by the use of a special tool, five hundred cards can be cut in an hour, and three hundred put on the plants in the same time. The most effective application for killing the maggots was found by Slingerland to be an emulsion compounded of a quart of soft soap, dissolved in a gallon of boiling water with a pint of crude carbolic acid; this mixture is diluted with thirty times its bulk of water, and applied with a syringe or sprayer.



FIGS. 11–15.

Fig. 11.—Cabbage-fly (*Phorbia brassicæ*), male; × 4. Fig. 12.—Hind leg of *P. fusciceps*; × 4. Fig. 13.—Maggot of *P. brassicæ*, from above; × 4. Fig. 14.—Tail region of maggot, with spiracular plates, from behind; × 10. Fig. 15.—Slit card for protecting roots; reduced one-half.

In this country the usual practice is to apply lime for the destruction of the maggots, and soda nitrate for the stimulation of the crop.

The Diamond-back Moth.

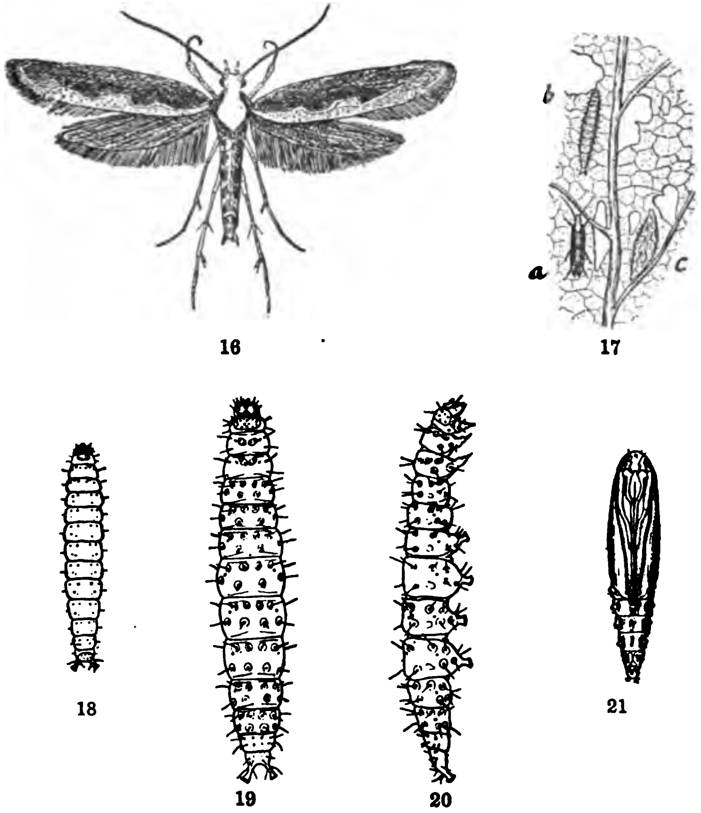
Plutella cruciferarum, Zell.

The past summer will be remembered for the prevalence of "Diamond-back" caterpillars among our cruciferous farm-crops. This moth is always present and in considerable numbers; but in certain years, either by the presence of especially favourable life-conditions, or through immigration of flocks of moths from the Continent, it multiplies to an alarming extent, and does great damage. This moth was destructive in Great Britain in 1898, 1897, and 1894, but the great "Diamond-back" year was 1891, when the insects abounded in Great Britain and in Ireland, especially along the eastern seaboard in both countries (15).

In 1901, so far as our information shows, the presence of the insect was only noticed on the east coast:—near Dundalk (by Mr. T. J. Thomson); at the Albert Model Farm, Glasnevin, Dublin; and in county Wicklow (Bray and Greystones). Through the kindness of my friend, Mr. R. M. Barrington, I had a good opportunity of studying the ravages of these caterpillars in his turnip field at Fassaroe, near Bray. (16)

The moth is only about ¼ inch long, and the wing-spread ¾ inch, but its markings are very distinct. The top of the head is white, and this white scaling is continued backwards in a broad band along the forebody, widening between the wing-bases, and tapering behind. The forewings are greyish-brown, with black spots and mottlings; along the inner margin of the wing runs a yellowish band that shows three successive widenings with constrictions between them. Consequently when the moth is at rest with its wings closed, and these inner margins contiguous, the appearance is that of three light-coloured diamonds in a row, whence the insect's English name. The hind wings are dark slaty grey (figs. 16, 17*a*).

The female lays her eggs beneath the leaves of various cruciferous plants. The small spindle-shaped caterpillars are at first grey or yellowish with black heads (fig. 18); then as they become fully grown, bright-green, the various segments with black bristle-bearing spots, each enclosed in a dull ring-like area, and the head brownish-yellow, with black mottling (figs. 19, 20).



FIGS. 16-21.

Fig. 16.—Diamond-back Moth (*Plutella cruciferarum*); × 4. Fig. 17.—Piece of turnip-leaf, with (*a*) moth at rest, (*b*) caterpillar, and (*c*) cocoon; natural size. Fig. 18.—Young Caterpillar; × 4. Figs. 19, 20.—Full-grown Caterpillar; × 4. Fig. 21.—Pupa, from beneath; × 4.

(From *Journ. Dept. Agr. Tech. Inst. Irel.*, vol. 2.)

The caterpillar feed beneath the cabbage and turnip leaves, at first gnawing away the lower leaf skin, and the green pulp in small patches, afterwards eating the leaves into large holes (Plate I., B), and finally devouring everything except the veins. When disturbed they often let themselves fall by means of a silken thread, afterwards climbing again to continue feeding. The spindle shape of these caterpillars, tapering towards both head and tail ends, and the divergent tail claspers are most characteristic.

When full-fed, the caterpillar spins a cocoon formed of a silken network, usually rather loose, which is fixed close to one of the larger leaf veins (fig. 17*c*). In this shelter it casts its skin and reveals the pupa, which is streaked with dark-brown and white, the sides of the hind-body segments bearing blunt tubercles (fig. 21). After two or three weeks the pupal skin splits open, and the moth emerges, the empty pupa-skin remaining attached to the cocoon by a few silken threads that are fastened to the hooks at the hinder-end.

The Diamond-back Moth has two broods each year. From the eggs laid by the moths that fly in May are hatched caterpillars that feed through June and July, and complete their transformation so as to appear as moths in August and September. The offspring of these—the second brood of caterpillars—feed on during September and October; then they spin cocoons on dead leaves lying on the ground, or on the stalks of perennial weeds, and pupate. The insects winter in the pupal stage, the moths not emerging until the next spring. The life-periods of the two broods overlap to some extent. In the Fassaroe turnip-field at the end of July, the caterpillars of the first brood could be seen feeding on the leaves, while many moths of the second brood had already come out, and were flying about in search of suitable spots for egg-laying. During August the late full-fed caterpillars of the first brood, and the young ones of the second brood can be seen together. It is difficult to reach these caterpillars with any destructive dressing, because of their habit of feeding beneath the leaves. Such natural remedies as heavy pelting rain that soils the undersides of the leaves, or the visits of seagulls, starlings, and other insect-eating birds probably do more good than any artificial applications. But it is possible by constant scuffling or horse-hoeing to knock many of the caterpillars off the plants and bury them. They can also be destroyed by soft soap and paraffin mixture—5 lbs. soap and 5 pints paraffin to 100 gallons of water. But dry dressings, that act as a stimulating manure are perhaps more effectual—for example 10 cwt. soot, 8 cwt. soda nitrate, and 1 cwt. ammonia sulphate, scattered broadcast at the rate of 1 cwt. per acre. A simple application of soot, or soot and lime, 2 cwt. to the acre, sown by hand with a low upward delivery when the dew is on the plants, so that it sticks to the under surface of the leaves, has been found very useful. Mr. Thomson tells me that during this year's attack near Dundalk in August, he tried spraying with salt and water, and also dressing with warm slaked lime, "the operators walking through the rows and shaking it on by the hand." He writes: "The latter produced the best result by far; soon after this some rain came, and we got rid of the pest for the season."

CORN INSECTS.

The Frit Fly.

Oscinis frit (Linn.).

This is the only insect injurious to grain crops of which I heard during the year, but its ravages, in parts of the country at least, seem to have been serious enough. Towards the end of September, Mr. S. Leigh, of Abbeyleix, Queen's County, wrote to the Department of Agriculture, calling attention to the failure of the oat crop in his neighbourhood. "I did not," he writes, "see within a radius of ten or twelve miles a sample of oats that I would offer to a farmer for seed." He forwarded a multitude of small black flies, which were readily identified as *Oscinis frit* (Linn.) = *O. vastator*, Curtis.

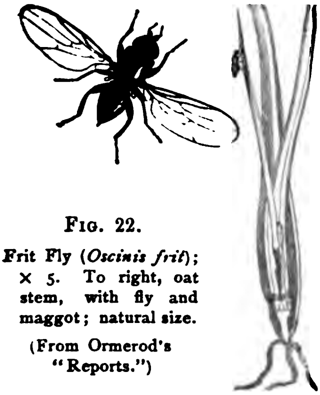


Fig. 22.

Frit Fly (*Oscinis frit*); × 5. To right, oat stem, with fly and maggot; natural size.

(From Ormerod's "Reports.")

This fly, measuring less than $\frac{1}{8}$ inch in length, has a brilliantly shining black body, and delicately transparent wings, somewhat clouded along the front edge; the legs are black, with brown or yellow foot segments (fig. 22). The prominent front corners of the fore-body are very characteristic of this insect. The maggot is white and fleshy, and the last larval skin hardens to form the brown barrel-shaped pupa case usual in this group of two-winged flies.

There are three generations in the year. The first brood of maggots feed in spring (April–May) in the lower region of the stalk; the second brood are found in July in the young ears of the corn, and also in the stems of meadow-grasses. The autumn flies sent from Abbeyleix had evidently developed from this brood. In the ordinary course, they lay their eggs on leaves, and the resulting third brood of maggots feed in the haulm of winter oats, or on the stems of grasses during October and November. This brood winters in the pupal state, the brown barrel-shaped pupa-cases remaining in the plants where the maggots have been feeding.

It is generally agreed that early sowing is an excellent preventive against the attacks of this fly, as the females which come from the wintering pupæ usually choose the late-sown crops for egg-laying. It would also be an obvious preventive to grow the next crop of oats as far as possible from the infested area. This is especially the case if winter crops are attacked by the maggots, as it is found that neighbouring crops in the next spring usually suffer also. (7)

A stimulating dressing (*e.g.* 1 cwt. soda nitrate per acre), applied when the plants first show signs of drooping, has been found to save—at least partially—an attacked crop. It is advisable to plough a hopelessly lost crop deeply into the soil, as the maggots or pupæ will be killed if buried far down.

BEAN AND PEA INSECTS.

Bean Beetle.

Bruchus affinis, Fröl.

In my Report for 1898, I mentioned the presence of this insect in broad beans imported from France by a Dublin seed merchant. In April of last year the same beetle was detected by Dr. G. H. Pethybridge, in beans procured for use in the botanical laboratory at the Royal College of Science. So badly infested were these seeds, that it was hardly possible to induce any of them to germinate. In their own interests, farmers should be on their guard against seed infested in this way. Not only is the germinating power diminished or destroyed, but the beetles thus introduced into the country will lay their eggs on the flowers of the next crop. The grubs hatched therefrom will feed, and the resulting beetles will develop within the growing seeds, a continuance of the infestation through successive years being thus assured.

Pea Weevil.

Sitones lineatus, Linn.

Specimens of the Striped Pea Weevil were sent early in May from Ballyshannon by Dr. R. H. Creighton, who wrote that they were "doing a lot of damage to young sweet pea." They frequently attack green pea also, as well as beans and clover. Like most weevils, these insects devour the plants both above and under ground, the beetles eating the leaves, and their grubs the roots. The damage to the leaves is, however, the more serious.

Dr. Creighton informed me that watering with paraffin and soft soap solution checked the mischief slightly, but that dressings of hot lime and soot were quite useless—"they seem to enjoy it rather than otherwise." The late Miss Ormerod, in her account (17) of these beetles, lamented the difficulty of finding any effectual remedy for their ravages. Most of her correspondents, like Dr. Creighton, found soot and lime useless, the only dressing that was reported to have given good results, being soot mixed with soda nitrate, which acted probably rather by pushing on the crop than by killing the insects. The damage to the young leafage is begun in early spring by beetles that have survived the winter, and the second generation of beetles does not come above ground till June. It has been found, therefore, that late sowing—matters being so arranged, that the tender leaves shoot forth after the first brood of beetles have died, and before the summer brood appear—is often a safeguard. The beetles may sometimes be found swarming in the fields at harvest time. If left alone, many of these will survive the winter, and do much harm next spring. They should therefore be collected and destroyed, wherever opportunity offers.

MANGOLD INSECTS.

The Mangold Fly.

Pegomyia betæ (Curtis).

Every year the leaf-mining maggots of this fly do more or less damage to our mangold crops. Through the kindness of Mr. T. Alex. Rudd, I received in June samples of mangold-leaves, from near Sallins, county Kildare, badly blistered by these grubs. The fly is allied to the parent of the cabbage-root maggots described above, but on account of the spindle-like shape of the male's hind-body, the mangold fly falls into the genus Pegomyia. As mentioned above (p. 142) Phorbia, the genus of the cabbage-flies, is characterised by the parallel-sided hind-body of the male.

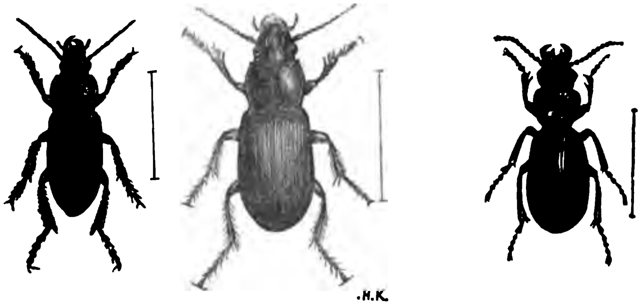
The only sure way of destroying these maggots seems to be to pinch them in the blisters, or to pick off the blistered leaves and burn them. On no account should these leaves be left lying about, so that the maggots have a chance of completing their transformations. It is likely that many farmers would consider this hand-picking work too troublesome and expensive for use on a large scale. The application of nitrate of soda to an infested crop has been known to help the plants to come fairly well through a bad attack. (17)

Ground Beetles.

Pterostichus vulgaris, Fab., and *Harpalus ruficornis*, Fab.

Early in July, the editor of the *Farmer's Gazette* sent some mangold roots, from near Augher, county Tyrone, that had been bitten through just above the surface of the ground by some undiscovered insects. The appearance of the injured roots led me at once to suspect large ground-beetles as the authors of the mischief, and this conjecture was confirmed by the receipt shortly afterwards of specimens of *Pterostichus vulgaris*, and *Harpalus ruficornis* which had been found in the attacked field. These two species together with *Pterostichus madidus*, Fab. a very common beetle in Ireland, have been noticed by Miss Ormerod as injurious to mangold roots in certain localities in England (18). The black species of Pterostichus are very familiar insects. In *P. vulgaris* the hind-corners of the fore-body shield are prominent (fig. 24), while in *P. madidus* they are rounded (fig. 25). *Harpalus ruficornis* (fig. 23) is a very common insect easily recognised by its red legs and feelers, and the golden pubescence covering the wing-cases.

The root-eating habits of these beetles are specially interesting to the naturalist, because the family of ground beetles (Carabidæ) are, as a whole, insects of prey, devouring vegetable-feeding grubs, and acting therefore as benefactors to the farmer. But the ravages on crops committed by some members of the family have long been known in North America, as well as in our own countries. The difficulty of destroying these destructive ground beetles is due to their habit of feeding by night; during the day they hide under clods or stones, or bury themselves in the earth. But in describing the attacks of these beetles on ripe strawberries (*l.c.*, pp. 123–6), Miss Ormerod records the great success that attended the efforts of some cultivators to catch them in traps. Basins or old preserving tins baited with meat, and sunk with their edges level with the ground-surface, served to capture a large number of the insects. They can also be caught lurking beneath sacking, straw, or similar shelter-traps laid for them, especially if baited with some strong-smelling meat.



GROUND BEETLES.

FIG. 23. *Harpalus ruficornis*; × 1½.

FIG. 24. *Pterostichus vulgaris*; × 1½. (From Ormerod's "Reports.")

FIG. 25. *P. madidus*; × 1½.

FLAX INSECTS.

The Flax Flea-Beetle.

Longitarsus ater (Fab.).

So few observations on insects injurious to flax have been made in this country that the presence, last June, of numbers of small flea-beetles upon the crop near Lisburn is especially noteworthy. These beetles, which were sent by a correspondent of the Department of Agriculture, proved to belong to the species *Longitarsus ater* (Fab.). It is remarkable that this same beetle almost destroyed the flax-crop in county Down in the year 1827, as recorded by the late Robert Patterson of Belfast (19). The insects are to be found within the opening leaf buds, and they eat the young tender leaves into nicks and holes (fig. 27).

This beetle is related to the notorious "turnip-fly," agreeing with that insect in its strong hind-thighs that enable it to leap far and high. But the genus Longitarsus is distinguished by the exceedingly long basal segment of the hind-foot, with which the succeeding segment articulates by means of a ball-and-socket joint. *L. ater* is a very small beetle, only about $\frac{1}{11}$ inch long; the fore-body and wing-cases are of an uniformly dark pitchy-brown or black colour, sometimes showing a metallic bronzy lustre, and are impressed with numerous very fine punctures. The four or five basal segments of the feelers are yellowish-brown, the rest dark. All the legs are yellowish or brownish, except the thick black hind-thighs (fig. 26). *L. ater* is generally distributed in Ulster, but elsewhere in Ireland it has only been found near Waterford.

On the continent our common "turnip-fly" (*Phyllotreta nemorum*) is known as an enemy to growing flax-crops. Probably some of the means adopted for the destruction of that insect would be effectual against the Longitarsus. Dr. R. Kuwert, in his work (20) on flax-culture, recommends dusting the attacked plants with dust from limestone highways, or watering with a chloride of lime solution. A decoction made by boiling a handful of wormwood in a pailful of water for twelve hours has also proved useful.

This may be applied alone or used with a mixture of guano (one part), sulphate of lime (one part), and wood ashes (four parts) applied as a damp dressing. Strewing the ground with horse-dung and coal-ashes when the seed is just germinating is said to act as a preventive.

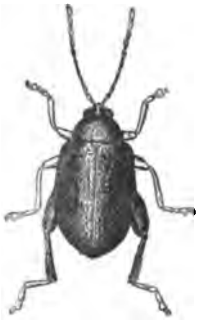


FIG. 26.

Flax Flea-beetle (*Longitarsus ater*); × 12.

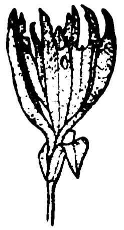


FIG. 27.

Injured Flax-shoot; × 3.

(From *Journ. Dept. Agr. Tech. Inst. Irel.*, vol 1.)

Other insects mentioned by Dr. Kuwert as injurious to flax are the Mole Cricket (*Curtilla gryllotalpa*, Linn.), almost unknown in Ireland, the caterpillar of the Silver Y. moth (*Plusia gamma*), and the caterpillar of the bell moth *Conchylis epilinana*.

ORCHARD INSECTS.

Pear Thrips.

Thrips physopus, Linn., and *T. flava*, Schr.

In my report for 1900, reference was made to the injury caused to pear-blossoms near Dublin by the attack of these two species of Thrips. Dr. Barton tried a dressing of kainit around the trees in the early spring of last year, before the opening of the buds, with very satisfactory results, as the trees bore a good crop of fruit in the autumn. It seems, therefore, that these, like some other species of Thrips, spend the winter in the ground near their food-plants. The application of kainit is an excellent remedy for the destructive pear midge (*Diplosis pyrivora*, Riley).

It is possible that the failure of the trees in 1900 was due to the presence of the grub of the latter insect. Pears infested with the characteristic little yellow maggots were sent to me in June, but I heard that they had been imported from England.

The Plum Aphis.

Hyalopterus pruni (Fab.).

Early in June, shoots of plum badly infested with Aphids were sent by Colonel Everard, of Randlestown House, Navan. The species proved on examination to be *Hyalopterus pruni* (Fab.), and most of the individuals belonged to a red variety of the wingless female comparable to that of *H. mali*, the apple Aphis. The genus Hyalopterus is easily recognised on account of the extreme shortness of the cornicles.

FOREST INSECTS.

The Pine Weevil.

Hylobius abetis (Linn.).

In December I received from the neighbourhood of Cappoquin, Co. Waterford, shoots of Scotch fir and Larch, from which the bark had been almost completely gnawed away by weevils (Pl. I., c). The injury was far worse than any due to this insect that I had before seen, and I was informed that the beetles had been gnawing at the trees up to the end of September.

There can be little doubt that, somewhere near the injured plantation, felled trunks, stumps, or logs must have been left lying about in sufficient numbers to form the breeding ground for an unusually large colony of these insects. The beetles pair at midsummer, and the female chooses such objects as those just mentioned for her egg-laying, because in them the young grubs will find the most suitable life-conditions. In growing trunks and shoots, the flow of sap is too strong for the grubs to endure; consequently the practice of leaving felled trunks, logs, lopped-off branches, &c., about a plantation is the surest way of encouraging a visitation of this and other injurious beetles. But by the judicious placing of such things to serve as traps for the insects, and periodically collecting and burning them, the numbers of the beetles can be greatly reduced.

HOUSEHOLD INSECTS.

A Tropical Black Ant.

Iridomyrmex humilis, Mayr.

In December, 1900, I received from Mrs. Corry, of Windsor Park, Belfast, an inquiry respecting a plague of ants that had infested her house for the previous eighteen months. Specimens that she kindly forwarded at my request showed me that the ants belonged neither to one of our native species, nor to any of the various exotic kinds that have been so far noticed among us as introductions. Only recently, by the courteous help of Dr. A. Forel, has the insect been identified as a tropical American ant, *Iridomyrmex humilis*, Mayr., widely distributed from Mexico to southern Brazil, and a few years ago introduced into Madeira, where, says Dr. Forel, "it is now the house ant par excellence."

The appearance of these ants in swarms at so northern a locality as Belfast is, therefore, of considerable importance. Mrs. Corry has kindly written me a detailed account of her observations on their habits and mode of occurrence, from which, by her courteous permission, I quote the following notes:—

"The ants were first observed in the conservatory and vinery: the latter is a lean-to against our back premises, and thence they appeared to get through into the laundry. One morning we found them crossing the kitchen yard in a dark army, quite three inches broad, into the larder, where a leg of mutton and a fowl became so covered with the insects that one could scarcely find room for a pin-point. With great difficulty we managed to banish them from the larder by means of many washings and the free use of paraffin oil, but not before they had made their way into the scullery, cook's pantry, and kitchen, from whence they swarmed into the adjoining pantries. . . . They increased until they swarmed over everything, and housekeeping became a great toil, as we were obliged to keep everything eatable in basins of water. At the end of October [1900] I set men to excavate and clean out every particle of soil from under the benches and in the conservatory and vinery, and to dig deep down to find the nests of the ants. At a depth of 3 ft. 6 in. or 4 ft. about eight very large nests were found. When these had been cleared quite away and destroyed, and copious quantities of boiling water, mixed with paraffin, tobacco-water, and soft soap, thrown everywhere, so that the place was flooded, we hoped to have seen the end of them; but they swarmed again, as numerous as ever. I then had all round the other side of the house excavated, and shrubs and climbing-plants removed. One large nest was found deep down at the foundation, and this led to our excavating in under the house. Beneath the pantries, kitchen, and sculleries nests were found everywhere 3½ ft. to 4 ft. down. Every bucketful of sand was swarming with them. They did not come up through the floors, but inside the walls and out at the framework of doors and windows.... The greater number of the insects seemed to rest from two o'clock in the day till after eight in the evening. Consequently one was always creeping under the floor and following their armies about till midnight, and often later. We opened large holes at spaces from each other, removing sand and soil, and building piers of brick to sustain the floors, first saturating all around with paraffin oil. . . . The ground on which our house is built was a nursery-garden at one time, and the spot chosen was high in the front, sloping downwards behind, the soil being pure red sand. The builders levelled up the back part with soil (dark loam) from the bottom garden, and it was in this loam that the ants occurred.

"We had to destroy the nests as well as the swarms coming and going; for that purpose we always had, close by, tins with paraffin ready to throw on a swarm when dislodged. It was not until all the soil had been removed from under the floors of the back-premises that we got rid of the ants. All the soil congenial to them has now been removed to a distance, and thrown into bog-meadows that are always under water, and the soil, as it was thrown into barrows for removal, had boiling-water poured over it. Now (January, 1902) we have been quite rid of the ants within the house for about a year. In April there were still swarms of them in the fernery, but these were got rid of, the conservatory and vinery having been previously cleared, though there are still some in the stove-houses in the garden."

The very drastic measures taken by Mrs. Corry have, happily, succeeded in clearing the house of these serious pests, and it was not found necessary to adopt a suggestion of mine, that the whole area of the house should be completely concreted over between the foundations. This practice, however, if adopted when a house is first built should effectually keep out all undesirable animal guests.

I asked Mrs. Corry, if any attempt had been made to trap the ants, and she replied that enormous numbers had been caught in bottles baited with pieces of meat or sweet fluids, but nothing short of exterminating the nests succeeded in abating the plague.

It is to be hoped that this ant may not establish itself permanently in our islands. The fact that it could multiply and flourish to such an extent in a northern locality should lead householders to be on their guard.

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I cannot close this Report without dwelling on the loss sustained by students of insects in Ireland, as elsewhere, through the lamented death of Miss E. A. ORMEROD in June last. Her wide knowledge and ripe experience were ever at the service of Irish inquirers, and it is hard to realize that the kindly help and encouragement that for so long cheered us can be ours no longer. We can best honour her memory by doing what we can to carry on her work.

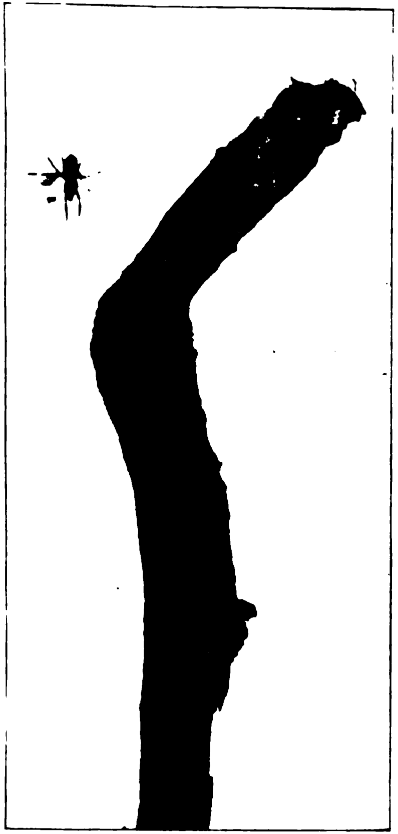
[Explanation of Plate, p. 160.

EXPLANATION OF PLATE I.

A. Cabbage-root injured by *Phorbia brassicæ.* Above white eggs, below which is a puparium partly imbedded in root; towards lower end of root two maggots are seen burrowing; × 1½.

B. Turnip-leaf injured by Caterpillar of *Plutella cruciferarum*; two-thirds natural size. (From *Journ. Dept. Agr. Tech. Inst. Irel.*, vol. 2.)

C. Pine-twig with two specimens of *Hylobius abetis* gnawing bark; × 1½.



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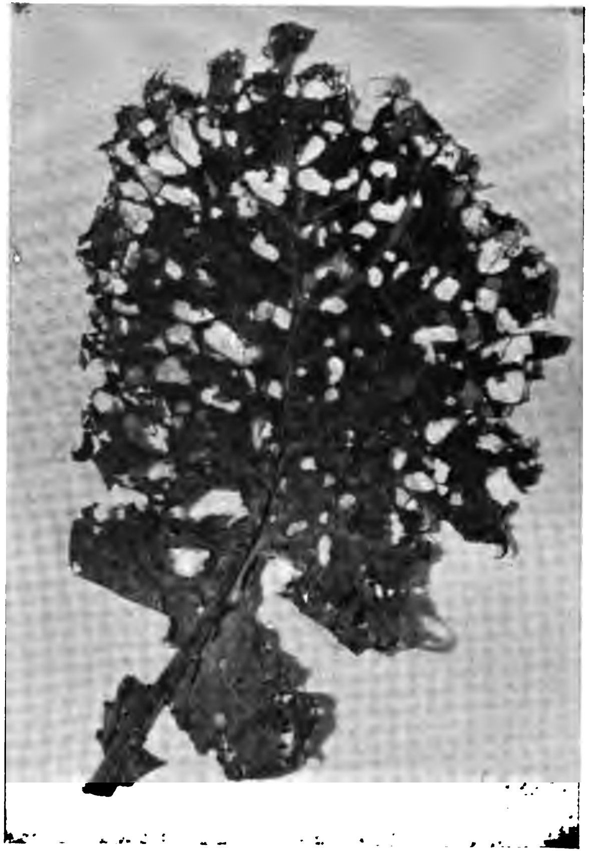

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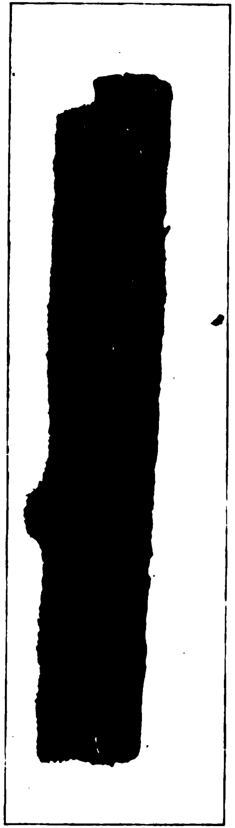

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VI.

PHELLOMYCES SCLEROTIOPHORUS, FRANK : A CAUSE OF POTATO SCAB AND DRY ROT. BY T. JOHNSON, D. Sc., F.L.S., Professor of Botany in the Royal College of Science, and Keeper of the Botanical Collections, Science and Art Museum, Dublin.

(PLATES II. AND III.)

[Read NOVEMBER 18; Received for Publication NOVEMBER 21, 1902;
Published APRIL 21, 1903.]

THE term Scab, with its foreign equivalents, is made to do duty for quite a number of different kinds and degrees of disturbance to the normal condition of the skin of a potato. In some cases, the disturbance is in the form of dark-coloured swellings, scarcely penetrating into the skin—*e.g.*, often in *Rhizoctonia* scab. The chief damage in such a case is apparently one of appearance. The tuber is unsightly for culinary purposes. Sometimes the scab is in the form of distinct depressions in the skin, more or less deep, and associated with a microbe, and too moist conditions of cultivation, so that the physiological functions of transpiration and respiration are interfered with, and injury in the form of scab results. This inclusion of different kinds of skin-trouble under the one term of scab, with different agents at work in the production of the diseased condition, is largely responsible for the want of agreement in the experiments of different writers as to the best means of preventing scab in potatoes. In the following remarks, I wish to call attention to a form of potato scab, which, though only once before noticed, is, I think, widely prevalent.

In the course of an examination of a number of potato-tubers last autumn, I noticed some, of which the skins were, in patches, discoloured, showing over their surface minute black specks $\frac{1}{250}$ inch in diameter, just visible to the naked eye, and not removable either by one's nail or by scrubbing-brush. Microscopic examination of these specks showed that they were true sclerotia, but hundreds of times smaller than the sclerotia of the "stalk" disease. My first impression was, that I had met either with a new stage in the life-history of the Sclerotinia fungus, or that I was dealing with a fungus which had not hitherto come under the observation of botanists. On consulting the literature on potato diseases, however, I found the specks had already been met with, and investigated in Germany by Frank. The fungus has been named by him *Phellomyces sclerotiophorus.* It has not hitherto, as far as I know, been observed in the United Kingdom. I have found it on tubers of many different varieties from various parts of Ireland. It is a true parasite, and apparently may do considerable unsuspected damage to the potato crop. It may give rise to a skin-disease or "scab" of the potato-tuber, and, in a more advanced stage of attack, to a potato-rot.

In the scab stage, it is indicated by the presence, in the potato skin, of larger or smaller patches of various colours, in an otherwise sound tuber. It may form whitish, shining patches when the outermost layers of the cork cells of the skin are infested by the fungus threads, and are loosened from the rest of the skin. In other cases, the patches are often light-brown in colour. They are well seen, *e.g.*, in the red-skinned variety, "Black Skerries." The brown colour of the patch is due to the fact that the fungal hyphæ or threads have grown from the surface through the cork cells of the skin into the cork-forming layer or living cork-cambium, and even below this into the living starch-containing cells. When the patches are abundant and fuse together, the skin becomes strongly scabbed. In the patches, as a rule, but not always, the dot-like sclerotia occur. In the scab stage, the fungus is chiefly harmful, in that it tends to loosen and peel off layer after layer of the skin of the tuber, thus robbing it of its protective coat. The sclerotium consists, as seen under the microscope, of black short cells, filling more or less completely the brick-shaped cork cell. Occasionally one fills two adjoining cells. Sometimes the sclerotia, which ordinarily scarcely project above the surface of the tuber-skin, are found deeply imbedded either in the skin or beneath it. The sclerotia of *Phellomyces*, in size and position, are readily distinguished by the naked eye from the sclerotia of *Rhizoctonia*. Microscopically, the cells of the sclerotium of *Phellomyces* show deep-black violet or dark-brown walls; whereas in *Rhizoctonia*, in the much larger, looser-built, superficial projecting sclerotia, the cells are twice the diameter, and have light-brown or reddish-brown walls. An important point—not to be overlooked—is that the sclerotia of *Phellomyces* may not be present until about the time of—or even after—the harvesting of the crop.

FURTHER STAGE IN THE PHELLOMYCES DISEASE.

Sometimes the skin of the potato-tuber peels off over the greater part of the surface like paper, taking with it the sclerotia which had formed, and leaving only the single layer of cork cells, or not even this layer. In this stage, which may be regarded as the last stage of the *Phellomyces* scab, the starch-containing tissue is fully exposed, and a dangerous condition is brought about, and dry rot of the tuber easily occurs. In one infested tuber which I cut through and kept under suitable conditions, the cut surface became covered with sclerotia, and also became dry and powdery owing to the separation of the cells of the tuber by the penetrating fungal hyphæ.

PHELLOMYCES ROT.

The dry rot of the tuber due to the penetration of the *Phellomyces* fungus, is accompanied by the death of the cortical starch-containing cells, and the turning brown of their protoplasm. The storage cells die and separate, since the fungal hyphæ grow both between and through the cells. The starch grains themselves are not essentially altered. Under the microscope, they can be seen bored into by the fungal hyphæ—an effect which is quite different from that caused by the *Rhizoctonia* fungus. This dry rot causes a white, dry, powdery substance in the tuber, and is at first only found on tubers that have been in store. Sclerotia may also form naturally in the inner substance of the tuber in connection with the dry rot. Such sclerotia are the size of a pin's head, being much larger than the ones present in the skin in connection with the scab stage. *Phellomyces* is a mycelial or thread fungus, probably widely distributed in the soil of Ireland, and grows from the soil on to the potato-tuber. Seed-tubers infested with *Phellomyces*, introduce the disease into cultivation. Under artificial culture (gelatine, agar, and potato), I have found that the sclerotia are readily produced; but, up to the present time, neither in nature nor by culture, has any typical fungal fructification been observed.

PREVENTION EXPERIMENTS.

In the spring of this year, 1902, I received a quantity of tubers of the Champion variety, through the Congested Districts Board, from Mr. D. S. Simpson, one of the Board's instructors, from a district in which yellow blight is a common potato-disease. Examination of the tubers showed the presence of *Phellomyces* in plenty. A number of tubers were taken and soaked for one hour in 0·8 per cent. solution of formalin. The tubers were planted on April 28th—some in large pots, others in the ground, and inspected from time to time. On the 26th of September, the plants were [taken up and the tubers examined. They were found to be free from *Phellomyces*, and also, for the most part, free from *Rhizoctonia* scab, an unsightly potato-disease, and the cause of a rot extremely common in the West of Ireland. At the same time, a set of *untreated* "Champion" tubers, suffering from *Phellomyces*, was planted; and the control experiment showed the presence of *Phellomyces* in the tubers, resulting from the planting of the diseased seed-tuber. Had this control experiment not been made, it would have been unsafe to conclude that the freedom from *Phellomyces* of the crop resulting from the treated tubers was due to formalin. The change of climate and of soil, from the wet boggy land in the west to the comparatively dry loamy soil used in Dublin, might have accounted for the disappearance of the *Phellomyces*, without formalin treatment. It is, for example, not often that one finds the potato crop suffering from the "stalk" disease (*Sclerotinia sclerotiorum*) in the east of Ireland; but in the west there is scarcely any plot free from it. In the course of an inquiry into the nature of the yellow blight, I learnt from Dr. Delacroix, the Director of the Plant Pathological Institute in Paris, that, though the French potato crop suffers at times and in places severely from a yellow blight, the sclerotium fungus, *Sclerotinia sclerotiorum,* never occurs in France on the potato. To help me to clear up certain points in the life-history of *Sclerotinia sclerotiorum,* the Congested Districts Board got over from France several varieties—*Quarantine, Géante sans pareille,* and *Imperator*—and planted them in a district in Connemara in which yellow blight is very prevalent. All three varieties were attacked by yellow blight, and showed the stalk disease. More interesting still from our present point of view, is the fact that the tubers resulting from the planting of the French tubers, show *Phellomyces* abundantly present. This fungus must apparently have attacked them in the ground in Connemara, as it is not known in France. One could not wish for a better illustration of the *Phellomyces* scab than is provided by the French tubers grown in Connemara. Very little is known as yet of the life-history of *Phellomyces*; and one is unable to say, as yet, whether it is confined to the tubers or not. I am coming to the conclusion that the soaking of all seed-tubers in a weak solution of formalin or other fungicide before planting, at any rate in the west of Ireland, is highly desirable and would be profitable.

[EXPLANATION OF PLATES, p. 166.

EXPLANATION OF PLATES II. AND III.

Phellomyces sclerotiophorus, Frank.

Figures to illustrate the paper on a potato-scab and dry-rot due to *Phellomyces*; Plate III. drawn by Miss R. Hensman.

PLATE II.

FIG. 1. (*a* and *b*). Coloured illustrations of two potato-tubers affected by *Phellomyces* scab, *P*; and also showing sclerotia of *Rhizoctonia*, *R.*

Both tubers were taken from a crop of healthy French tubers imported by the Congested Districts Board, and grown in Connemara.

FIG. 2. Surface view of sclerotia of *Phellomyces* in old tuber skin, showing that the old seed-tuber not only can transmit the disease to the crop resulting from it; but may, if left in the ground, infect healthy seed-tubers planted near it.

PLATE III.

FIG. 1. Surface view of tuber skin showing the sclerotia (*S.*). × 65.

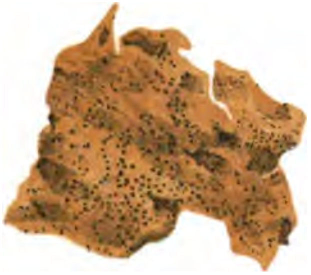
FIG. 2. The same, more highly magnified, showing the sclerotium (*S.*). × 300.

FIG. 3. Vertical section of the potato-skin showing the sclerotium (*S.*). *C*, cork-cells of periderm. × 340.

FIG. 4. Isolated sclerotium in first stage of germination. × 300.

FIG. 5. Starch-grains in process of perforation by fungal hyphæ; *h*, an attached hypha in section. × 300.

Plate II.



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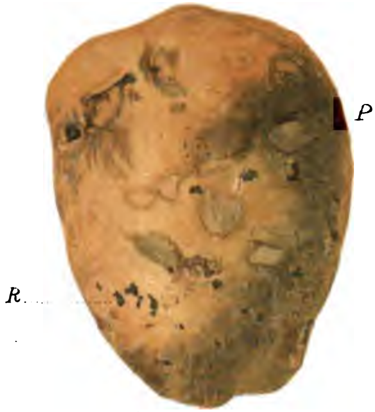

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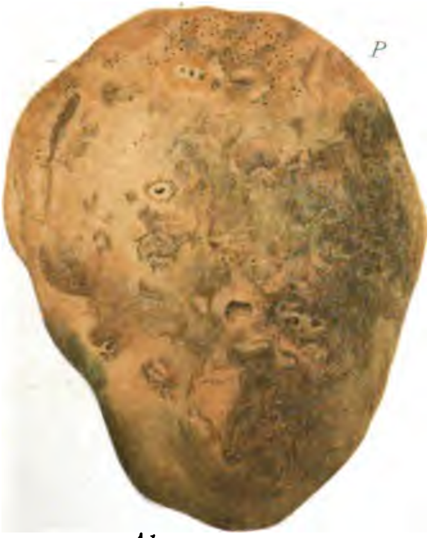

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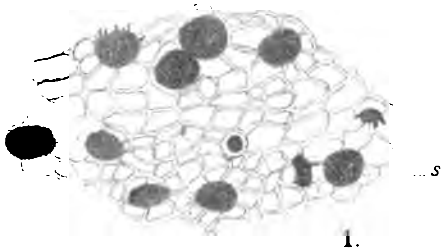

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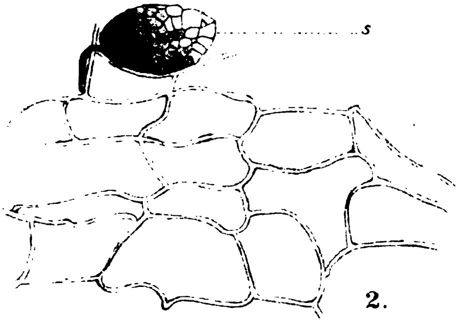

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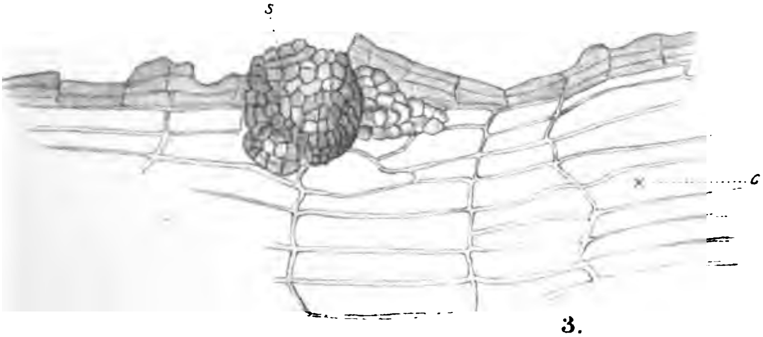

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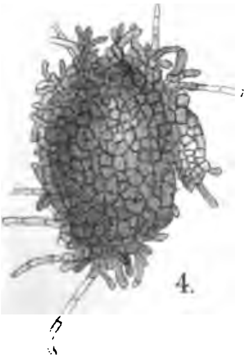

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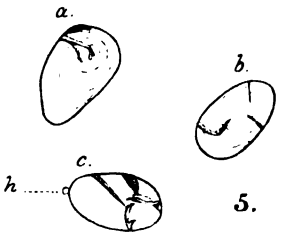

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VII.

ON THE DETERMINATION OF THE DEPTH OF LIQUIDS IN DISTANT VESSELS, DEEP WELLS, TANKS, ETC.

By LEONARD MURPHY.

[Read November 18, 1902 ; Published April 21, 1903.]

The determination of the depth of liquids in distant vessels is a subject of much importance to almost every factory, mill, or other centre of industry. Liquids are used in all, whether for the actual process of manufacture, for direct power, or for boiler supply; and the vessels which contain them are often difficult of access, or dangerous to approach owing to the nature of their contents if inflammable, explosive, or emitting suffocating gases. In most factories economy of water must be specially considered, constant attention is necessary to prevent waste by overflow, and, on the other hand, care must be taken to avoid the risk of running short at a critical moment.

In breweries and distilleries, the quantities of liquid dealt with are very great. Single vessels containing from 20,000 to 80,000 gallons are rapidly discharged, and their contents re-distributed to other vessels, often at a rate of 500 to 1,000 gallons per minute. Transfers of valuable liquids at this rate require strict attention, and are a constant strain on the men employed, owing to the primitive means which have hitherto been at their disposal of estimating depths on the receiving vessels.

In order to determine the contents of distant vessels, various means have been adopted.

1. Dipping-rods may be taken as the most usual means of ascertaining depths; but as these can only be used by approaching the vessels, they need not be considered any further here.

2. Gauge-glasses are often fixed immediately outside the vessels containing the liquids; sometimes, on the other hand, the glasses are set at a distance from the vessels by means of

connecting pipes; but they can only be used on the same levels as their respective vessels, and are therefore hardly an improvement on the dipping-rod.

The danger of breakage of the glass tube, and the probable loss of the contents of the vessel, has also to be kept in mind.

3. Floats, with flexible cables passing over pulleys, and with indicating pointers, are commonly used, and are fairly effective whilst visible in daylight. In most instances, however, the indicating-boards are attached to the sides of the vessels, and can only be seen, after dark, by approaching the vessels, and using artificial lights for the purpose. Attempts to lengthen the wire from the float, and carry it horizontally in order to indicate at a greater distance, are usually a failure, as the friction prevents the free action of the float, and the stretching of the wire adds to the difficulty of producing an accurate reading. Severe frost, too, interferes with this method by freezing the float to the side of the tank, where it often remains for some time after the ice has broken up, and the water-level altered in the tank. Unexpected variations in the buoyancy of the floats sometimes occur, due to saturation in the case of timber-floats and leakage where hollow metal-floats are used; and these variations produce corresponding degrees of inaccuracy in the results shown by the pointers.

For the above reasons, floats are not reliable when exact determinations of depth are required.

4. An ordinary pressure-gauge of the Bourdon type is sometimes used as an indicator of depth, when attached to a water-main, which takes its supply from an overhead tank.

A gauge so placed will show the pressure due to the depth of water in the tank, together with the head-pressure resulting from the vertical distance of the gauge beneath the bottom of the tank. The use of a pressure-gauge in this way is limited to a position beneath the vessel; and the reading shown by the gauge becomes proportionately smaller as the vertical distance between the gauge and the vessel is increased.

Thus, when a pressure-gauge is fixed—say, 50 feet beneath a tank containing 3 feet of water—it would register a pressure of 53 feet, and slight variations of depth in this tank would therefore form a very small part of the total pressure acting on the gauge, and could not usually be read on the scale with sufficient clearness to ensure an accurate determination.

5. Electrical indicators should apparently solve the difficulties of distance and of levels, as the wires can be brought anywhere; but the complication of the parts of most of the instruments in use renders them unreliable, and the contact-system of recording admits of only approximate accuracy. In one type of these instruments, a float, by its upward or downward movement, makes a series of electrical contacts in a transmitting-box fixed over the vessel—thus causing a current to pass each time through a wire leading to a receiving-instrument which has been placed in some convenient position.

The receiving-instrument is on the principle of a step-by-step telegraph-receiver, that is, an electro-magnet attracts an armature which, by means of a ratchet and paul, moves a hand one space on a dial each time. The hand advances as the tank fills, and reverses when discharging. The accuracy of the reading thus shown depends on the closeness of the contacts; and, in practice, they are seldom placed close enough to show less than one inch of depth at a time. The resulting intermittent record would probably be sufficiently near for some purposes, but would be entirely inadequate when accurate figures are required. With such a number of delicate parts exposed to damp in the case of the transmitter, and the necessity of depending for long periods on the power of a small battery, it is not surprising that, in actual practice, these instruments are not found reliable.

6. Another electrical system is worked by a variable resistance which is controlled by a float in the vessel, more or less resistance being placed in circuit as the water rises or falls. The receiving part of the instrument is worked as follows:—A button at the base of the instrument is pressed, and a current flows through a galvanometer, deflecting the needle. A movable handle on the recording dial is now turned till a figure is reached at which the galvanometer-needle returns to zero; the unknown resistance in the circuit has then been balanced as in a Wheatstone bridge; and the figure marked by the pointer should correspond to the depth of water in the vessel.

This machine has the advantage over the step-by-step instrument of having a smaller number of automatic working parts, and of giving an accurate reading of the state of the transmitter by measuring its resistance; but the means of obtaining that reading are much more complicated and require some skill, whereas the former instrument records automatically.

The transmitters of all these electrical systems, however, suffer from the same defects in being intermittently worked by a series of contacts, in being set in a position exposed to damp, and in depending on floats of variable buoyancy, as in the case of most mechanical indicators.

7. Another depth-indicator works on a pneumatic principle. A diving-bell, to the top of which a small metal tube is attached, is fixed in a tank or well; and the tube is then taken over the top of the tank to an ordinary pressure-gauge. Water is now admitted to the tank; or, in the case of a well, the bell may be lowered into it; the water, by its pressure, forces some of the air out of the bell into the air-pipe, and thus transmits some pressure to the indicating-gauge. A defect in this system is that only part of the total water-pressure reaches the pressure-gauge owing to the elasticity of the air, which causes it to yield, and allow some water to rise in the diving-bell; the column of water acting on the pressure-gauge will therefore be less than the actual column of water in the tank by the amount which has risen in the diving-bell, and the lesser depth will be shown by the pressure-gauge. This difference might be allowed for when marking the scale of the pressure-gauge; but if any addition to, or alteration in, the length of the line-tubing were afterwards made, a different reading would be obtained, though the depth of water in the well or tank remained unchanged. The reading of this instrument is therefore purely empirical; its scale must be adjusted for each separate position; and, even then, the reading cannot be relied upon, as it will be affected by the expansion and contraction of the enclosed air, due to changes in the temperature of the surrounding atmosphere. The slightest leakage of air from it would destroy all record, besides giving much trouble in re-setting the apparatus, particularly in a well where the water could not be removed to allow the bell to be emptied in position.

Having now pointed out some of the difficulties to be met with, and a few of the defects in the apparatus most commonly used, I wish to describe an instrument which I have devised, and which is constructed on a different principle from that of any of the apparatus to which I have referred.

In any depth-indicator, accuracy is the most important requirement; then, if possible, absence of floats, travelling wires, and of moving parts in the distant vessels. It is also desirable that there should be no danger of loss of liquid in case of breakage of the indicator. The instrument itself should be simple in construction, and the method of working it free from complication. All these conditions are, I would submit, attained in the instrument I am about to describe.

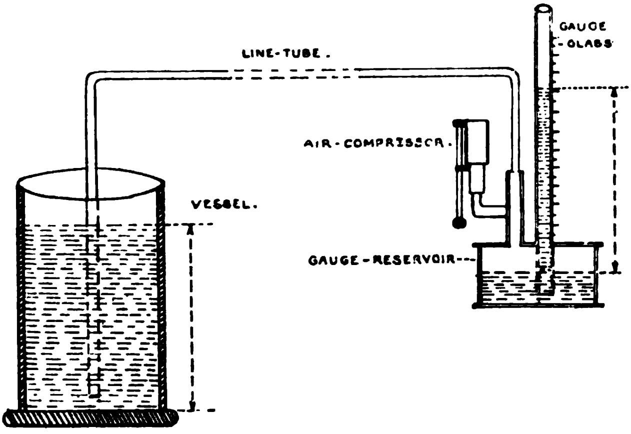

FIG. I.

8. I have called it the bathymeter. The motive-power is air; and the reading, which is shown by a column of liquid, is an absolute one, not empirical—that is, when indicating the depth of a liquid of a density similar to that used in the bathymeter, the latter will show a column of liquid of exactly the same height as that of the liquid in the vessel. One bathymeter can be used for any number of vessels; and it may be placed in any position relative to the vessels, above, below, or on a level with them. The principle on which it works, and the simplicity of its parts, can best be seen by the diagram, fig. 1.

The complete instrument comprises a small reservoir containing liquid, into which dips a gauge-glass, open at each end; from the reservoir an air-pipe leads to the vessel. This pipe enters at the top; while its open end is carried down and fixed near the bottom of the vessel. A branch from the air-pipe is connected to an air-compressor, as shown. Now allowing that the open vessel contains water to the height marked, the mode of working is as follows:—The lever of the air-compressor is raised, thus causing the compressor to take in a charge of air. On depressing the lever, the air becomes compressed, and rushing back, enters the air-pipe; here it is resisted at one end by the liquid in the gauge-reservoir, and at the other end by the liquid in the vessel. As the pressure of the air increases, the liquid rises in the gauge-tube of the reservoir, and continues to rise, until the air has overcome the resistance of the liquid in the vessel, and commenced to escape from the open end of the air-pipe in the vessel. The moment this occurs, the column of liquid in the gauge-glass ceases to rise; and its height will then be found to correspond exactly with the height of liquid in the vessel, provided that the density of each be alike.

In this instrument the air has been made the medium of a balance between two columns of similar liquids; and the balance thus produced is absolute, and is quite *independent of all irregularities in either the shape or size* of the apparatus used for producing it. The line-pipe may therefore be shortened, lengthened, or altered in diameter within reasonable limits without affecting the reading obtained after each stroke of the lever of the air-compressor.

In practice, this instrument has many applications; it not only overcomes distance and is independent of the levels of the various vessels, but it gives a clearer and more convenient form of reading than even the dipping-rod. When using the latter, the surface of the rod must be dried each time a duplicate reading is required; and if grease or oil be present, much difficulty will be experienced in getting the true figure. The bathymeter is free from these defects; each successive stroke of its lever produces a duplicate reading, which is entirely unaffected by the grease or other matter present in the vessel. It reads as accurately as a gauge-glass, with none of the disadvantages of the latter in case of breakage; and for that reason, and also on account of its great safety in working at a distance, this instrument is particularly suitable for oils, spirits, and other inflammable liquids.

Its range of power is very great, covering depths to some hundreds of feet, as will be shown presently. The instrument represented in fig. 2 stands about 5 feet high; and the gauge-tube is constructed to show a water-column intended for depths up to 4 feet; the parts are the same as those shown on the previous diagram—namely, a reservoir with gauge-glass, tube, and air-compressor, the only addition being a distributing pipe with connections for several vessels.

It will be easily understood that one bathymeter will serve any number of vessels, of course indicating one at a time. It is merely necessary to open the tap connected to the particular vessel, close the other taps, and make a complete stroke with the compressor-lever. The exact reading will then be shown on the rule. If the liquids in the vessels differ in density, a special rule is provided for those vessels requiring it, so that no calculation is necessary.

There are certain points of detail in this instrument which may be of interest, namely, the construction of the compressor, and the absence of valves in this part of the apparatus.

Air is exceedingly difficult to compress in definite quantities. When making the first compressor, it was found that the ordinary leather-faced plunger of an air-pump did not remain air-tight longer than a few months as a rule;

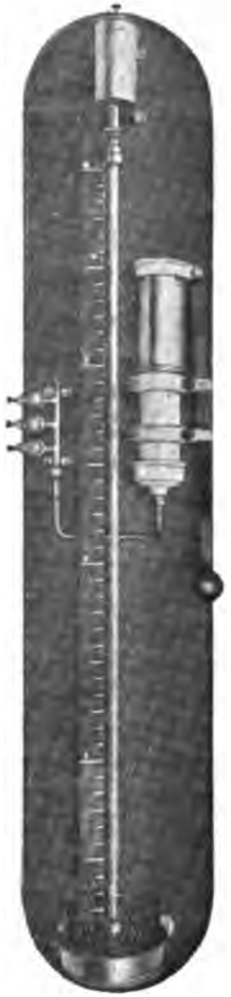

Fig. 2.

and, as a result, it soon failed to deliver the minimum quantity of air required.

This difficulty was completely overcome by the use of the bell-tube compressor; the latter consists essentially of a bell-tube which compresses air over a bath of mercury, and from within which an air-tube leads to the gauge-reservoir. The compressor will be understood on reference to fig. 3. It consists of two parts—(1) a cylindrical bell-tube, closed at the upper end, which, by lowering the lever of the compressor, moves down within the second part; (2) this latter is made up of an outer containing-tube closed at the bottom, and of such a diameter that the bell-tube can slide freely within it. A small pipe, to convey the compressed air to the gauge-reservoir, pierces the centre of the base of the containing-tube; it does not, however, terminate there, but is prolonged upwards through the centre, till it reaches a little above the top of the containing-tube.

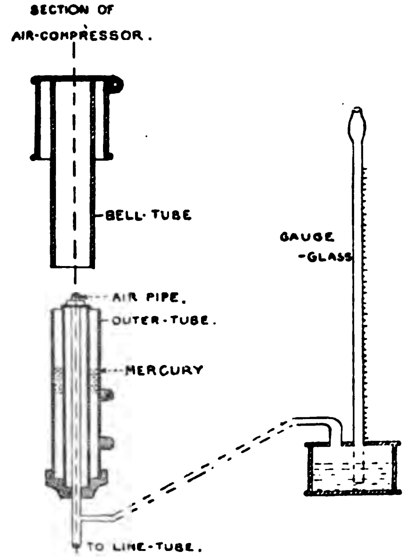

FIG. 3.

The portion of the air-pipe within the containing-tube is known as the displacer or displacing tube; for whilst its bore remains still small, its walls are enormously thickened; and it forms, as it were, a perforated plug, which fits closely, without actually touching the inner side of the bell-tube when the latter descends.

It is thickened in this manner in order to reduce the quantity of mercury required, and to displace the air from the upper part of the interior of the bell-tube during the compression stroke of the lever. It will now be understood that, during each stroke, the open end of the bell-tube descends through the mercury, and that the air thus enclosed in the bell-tube is forced out through the air-pipe under pressure.

The area of the bell-tube is such that the quantity of air driven from it during each complete stroke is more than sufficient to fill the whole apparatus and the line-tube, so as to ensure that some excess of air will pass out through the open end of the line-tube in the vessel, as shown in fig. 1. The first stroke of the compressor lever therefore produces an accurate reading on the gauge-glass; and succeeding strokes merely duplicate the results produced by the first. This mercurial compressor is very constant in its action; and as it does not depend on leather or other packing, it compresses a definite quantity of air at every stroke without loss or slip. The absence of valves in the compressor is a special point in this instrument; and they are dispensed with by making the compressor draw its supply of air through a liquid seal, either of water or of mercury. In the instrument just shown, the compressor draws its air through the gauge-glass. It will be seen that the gauge-glass dips into the liquid in the reservoir of the gauge, and that, during the up-stroke of the compressor lever, the air bubbles through this liquid, and on through the air-pipe to the interior of the bell-tube. During the down-stroke of the lever, the air cannot return through the gauge-glass so long as the pressure does not exceed the limit up to which the machine is designed to work.

There is an important difference between the method of connecting the bathymeter to each vessel and that adopted for the mechanical and electrical systems previously referred to—namely, that it is a fixture, no float or moving part being required. It is merely a small copper pipe, $\frac{1}{8}$ inch bore, passing through the cover of the vessel, and reaching inside to the bottom where the end is left open.

The simplicity of this connection enables it to be applied to every vessel—even to vessels where headroom for a dipping-rod is not available. There is nothing to be damaged or to go out of order; and a special feature is that it is unaffected by frost.

A water-column gauge-glass is seldom used in the bathymeter for vessels over 7 feet deep, owing to the difficulty which would be experienced in reading a longer column of liquid.

For deeper vessels, a mercurial column is substituted for the water-column. The scale is thus reduced in height to about $\frac{1}{13}$th of that of the former instrument, as the mercurial column, though little more than 22 inches long, is capable of dealing with vessels up to 25 feet deep.

The depth of liquid in large vessels of this kind is usually determined at present by .means of the dipping-rod—not a long rod, which would be unmanageable in a case like this, but by a short rod, which measures the dry inches between the top of the vessel and the surface of the liquid. This plan is applicable only to large vessels, which are usually filled almost to the top. When only partly filled, the ordinary rod is used; and the wet inches are measured, under unfavourable conditions, from the man-door or other opening, often several feet above the surface of the liquid.

For vessels such as these, the bathymeter is particularly suitable, as it gives a direct reading of any depth, and is not obscured by scum or froth on the surface of the liquid, which often renders accurate dipping with a rod an impossibility.

When measuring the depths of hot liquids, some differences may be noted between the depth shown by the ordinary rod and that by the bathymeter, of which the following may be taken as an instance:—20,000 gallons of water at 50° F. are placed in a heating-tank, in which the depth shown by both rule and bathymeter is 18 feet. The tank is heated externally to 212° F. without further addition of liquid. The depth is again measured, and the rod now shows an increase of about 10 inches, while the bathymeter still shows only 18 feet, as before. The weight of water in the tank is unaltered, though now expanded to a depth of 18 feet 10 inches; and, if cooled, it would return to its original bulk.

The rod therefore shows a different depth for each change in temperature of the same liquid; the bathymeter, on the other hand, shows a constant depth, unaffected by the variations in the temperature of the liquid it is measuring; and that depth will be in accordance with the temperature of its own indicating-column. This principle in the bathymeter should be of value when definite quantities of liquid at a constant temperature are required from a vessel of variable temperature, as by using this instrument, when drawing off the contents, equal weights of the liquid will be measured out each time; and these must occupy the same bulk when brought to the required temperature later on.

Having now dealt with depths up to 25 feet, it is necessary to refer to still greater depths; for wells are rarely less than that depth, and often run to several hundreds of feet. The determination of the depth of wells has until recently been practically neglected, owing to the extreme difficulty, and often danger, experienced in estimating them. It will probably be remembered that recently a manager and two of his men lost their lives in a brewery while dipping a well. A long rod was being used from a ladder, the first man was overcome by gases or foul air, and the others lost their lives in trying to save him. In another brewery, with a well 200 feet deep, in which the water varied 150 feet, the usual method of ascertaining the depth was by lowering a man down the shaft by means of a chair and tackle. This operation generally took over an hour, and was hardly worth the risk. From these two instances, it will be seen that the ordinary means of ascertaining depths are impracticable in the case of wells.

Recently, however, the bathymeter has been applied to these deep wells; and, by a simple arrangement, one instrument will indicate the depth of almost any well, and will show that depth to an inch, whether the well contains one foot or 100 feet of water.

One would naturally expect that a longer mercurial column would be used in such a case; but a practical limit would soon be reached in the size of the instrument, and for that reason the mercurial column is not lengthened; but by an arrangement of the line-tubing, to which I shall presently prefer, the instrument can, without any alteration, be made to indicate depths up to hundreds of feet. Taking, as an instance, the well last mentioned, which is now fitted with one of these instruments (fig. 4). This well is 200 feet deep: the water rises to within 50 feet of the ground-level, and the bathymeter was required to indicate the whole 150 feet of water. An ordinary mercurial bathymeter, scaled for 25 feet, was selected; and six connections, each fitted with a tap, were attached. These connections were numbered consecutively, 1 to 6; and, from No. 1, a small pipe was laid to the bottom of the well; from No. 2, a second pipe was laid, but ended 25 feet above the bottom of the well; from No. 3, a pipe was laid, 25 feet shorter than No. 2; and so on till the six pipes were fixed.

By this means, the well was divided into sections of 25 feet; and at whatever depth the water lay, some one of the tubes would give a reading of 25 feet or less, the other tubes showing either full or empty, as the case might be.

This tube was easily found by working the compressing lever of the bathymeter, and opening only one connection at a time. On obtaining an intermediate reading on the mercurial column, the number of the connection then open was noted, and the exact depth shown by means of a hexagon rule which was revolved till the face with a number corresponding to that on the open connection appeared. Opposite this face, the mercurial column clearly showed the depth of water in the well, as the rule-faces were marked from 1 to 25 feet, from 25 to 50 feet, and so on. As shown on the diagram (fig. 4), the well is almost full. A reading would be obtained on the sixth tube, and the depth shown by the mercurial column on the corresponding rule-face would be almost 132 feet.

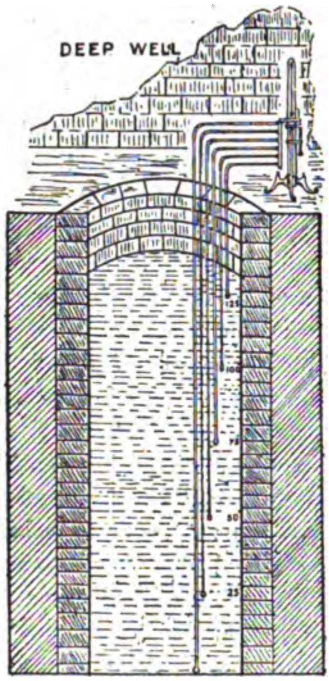

FIG. 4.

For practical purposes, the range of this instrument is almost unlimited; and where the liquid, whether water or chemical, is enveloped in dangerous gases, its use should obviate many dangers and difficulties.

VIII.

THE VALUE OF BACTERIOLOGICAL TESTS FOR SHOW-BUTTERS. By DAVID HOUSTON, F.L.S., Lecturer on Agricultural Bacteriology, Royal College of Science for Ireland.

(Plates IV. to VI.)

[Read February 17; received for Publication February 24; published May 22, 1903.]

The market value of butter depends to a large extent upon its flavour and aroma. The particular kind of flavour we associate with good butter is due to the presence of certain volatile substances held in solution by the fat. These substances are generated in the cream during the process of ripening, and, for the most part, are due to the action of bacteria. The particular kinds of bacteria associated with normal cream-ripening are those belonging to the lactic-acid-forming group. These bacteria, as is well known, attack the sugar-of-milk, and convert it into acid-of-milk: hence the souring and thickening that take place in ripening cream.

Undesirable flavours and aromas are, in most cases, also due to the action of micro-organisms working either in the ripening cream or in the made-up butter in store. Such organisms may be either bacteria, yeasts, or moulds; and the exact nature of the induced fermentations will depend upon the character of the particular forms of life that happen to gain an entrance to the butter, or to the cream from which the butter is made. The amount of casein, or, of course, other albuminous matter, retained in the butter has, under certain bacteriological conditions, an important influence upon its keeping-properties. Germs that produce undesirable changes in butter are usually associated with uncleanliness; and such contaminations may arise during milking, or by using unclean vessels or impure water, or by exposing the milk or the cream at any time to dusty air.

An objectionable flavour in a butter may be present from the first; or it may develop as the butter increases in age; but, under normal conditions, a good-flavoured butter, free from undesirable micro-organisms, will remain good-flavoured for a reasonable length of time; whereas, an originally good-flavoured butter, containing undesirable bacterial contaminations, will lose its original flavour and develop a different and objectionable taste and aroma in a comparatively short length of time.

A bacteriological examination will therefore yield important information concerning the grade of any particular sample of butter—information, in fact, that it is impossible to obtain in any other way.

With the primary object of collecting data for teaching purposes, I took the opportunity presented by the extensive collection of butters exhibited at the Winter Show of this Society, of securing samples, and submitting the same to a bacteriological examination. The general results are, I believe, of sufficient interest to lay before the Society.

In starting the work, I had two definite ideas in my mind. First, to get some information concerning the bacteriological conditions under which creamery butters are made in Ireland; and, second, to ascertain how far bacteriological tests agreed with the judges' awards.

Samples of all the prize-winning butters were examined, together with an unclassified sample (taken sometimes haphazard, and sometimes because it looked of inferior grade) from each class.

The method adopted was to weigh out (taking all due precautions to prevent contaminations) $\frac{1}{10}$ of a gram of the butter-sample, and to transfer it to 10 c.c. of sterile water in a test-tube, at a temperature of about 25° C. After thorough "mixing," the water was allowed to cool. So soon as the fat separated, and formed a thin layer on the surface, a $\frac{1}{10}$th of a c.c. was measured off in a sterile pipette, mixed with nutritive gelatine, and plated out in the ordinary way. In most cases a 2 per cent. lactose gelatine was used. As the colonies appeared on the plates they were counted, and sub-cultures made in different media. The number of gas-forming organisms present in any particular sample was estimated by first plating-out in lactose gelatine, as described; and then, when the gelatine solidified, a thin layer of ordinary gelatine was poured over its surface. If gas was generated by any of the colonies, it collected and formed a little bubble that was easily seen.

As there were, in all, ten classes, with three prizes in each class, thirty samples of prize-winning butters were examined, together with some additional samples that failed to obtain a prize. Creameries from all parts of Ireland were represented.

The inquiry was limited to a study of such of the living impurities as were likely to affect the commercial value of the butters. The line of inquiry will be best illustrated by giving, in the form of a table, the result of the biological analysis of one particular sample, selecting for this purpose the four exhibits examined in Class 56 ("Best-keeping Butter").

Table I.

Result of a Bacteriological Analysis of the Exhibits taking First, Second, and Third Class Prizes, together with an unclassified Sample in Class 56: "Best-keeping Butter in 2 lb. rolls, with not more than 1 oz. of salt to 2 lb. of Butter." Royal Dublin Society Winter Show, 1903.

The Butters.	Putrefying Bacteria.		Otherwise harmful Bacteria.	Apparently harmless Bacteria.	Moulds.	
	Rapid in action.	Slow in action.			Most objectionable.	Less objectionable.
First Prize, .	—	Numerous	—	Some	Some	Fairly numerous
Second Prize,	—	—	(?)	Numerous	—	—
Third Prize, .	Fairly numerous	—	—	Numerous	—	Fairly numerous
Not Classed, .	Very numerous	Some	(?)	Numerous	—	—

Many of the butters examined were above reproach; but others fell far short of the bacteriological standard of a good butter.

The unclassified samples, with but one or two exceptions, were always inferior to the prize-winning butters of the same class; but then, as before stated, an unclassified sample was often selected, because it looked inferior. Two samples (prize-winners) were discovered so heavily dosed with "preservatives," that no bacteria, good or bad, could grow in them. It is a question for the medical man to settle how far such butters are fit for human consumption. But it seems unfair to allow the use of "preservatives" in such competitions; and I think the Society would be well advised to disqualify, in future, butters so treated. If butter is made from clean milk, in a clean creamery, there is no necessity whatever for the use of preservatives. Preservatives are only of use in cases where it is important to hide the results of dirt.

It may be here mentioned that in connexion with this inquiry a number of the competing creameries were visited with the object of comparing the results of the bacteriological analysis with the actual state of affairs existing at the creameries. Amongst those so visited was one that had sent "preserved" samples of butter to the show, and *gained a prize*. A sample of buttermilk was taken direct from the churn into a sterilised bottle, and eventually submitted to a bacteriological examination, when the necessity for the use of preservatives soon became apparent. It was crowded with putrefying and gas-forming bacteria, together with wild yeasts and moulds, thus revealing the true character of the butter from a bacteriological standpoint. It is a good rule to go by in butter-judging—*discover preservatives, suspect dirt.*

Coming to details, we will now take the ten classes (Classes 53–62 in the Catalogue) in which competition was invited, and briefly review the chief bacteriological characteristics of each class as represented by the three prize-winning butters and the unclassified sample.

CLASS 53.—"*28 lb. Package, Unsalted Butter.*"

Of the three prize-winners, one was contaminated with putrefying bacteria (approximately 400 to the gram), evidently derived from foul water. The butter could not possibly keep long. In such a case as this, the extent of deterioration would largely depend upon the amount of casein left in the butter, and the temperature at which the butter was stored.

CLASS 54.—"*Twelve 2 lb. Rolls, unsalted Butter, suitable for London Market.*"

One sample was badly contaminated with both putrefying and gas-forming organisms—approximately 50,000 to a gram. The putrefying bacteria developed rapidly at room-temperature; and two days after the show, the butter was distinctly tainted. The gas-forming bacteria showed evidences of great activity at blood-heat, and a subculture of this, in a tube of sterilised milk, sealed with vaseline, and kept at summer-temperature, forced the vaseline out of the tube in two days.

A visit to the creamery, exhibiting this sample, strengthened one's confidence in the value of bacteriological evidence. The unclassified sample examined was undoubtedly superior to the prize-butter just referred to.

CLASS 55.—"*Twelve 1 lb. Rolls salted with 1 oz. salt to 6lb.*"

One of the exhibits contained a large number of slow-acting putrefactive germs that, given time, would eventually spoil the butter. Another was heavily dosed with a chemical preservative.

CLASS 56.—"*For Best-keeping Butter—not more than 2 oz. of salt to 2 lb. to be used.*"

The results of the examination in this class have been given already in Table I. above. Two of the butters were contaminated with putrefactive bacteria, that in one case grew very slowly, and in the other rapidly at room-temperature. The unclassified sample examined was distinctly bad and had no claim whatever to be included in this class ("*Best-Keeping*" Butter).

CLASS 57.—"*2 lb. saltless Butter from ripened Cream.*"

One sample was badly contaminated with putrefactive bacteria, and another contaminated with an organism that produced an unpleasant smell. Both exhibits were typical bad-keeping butters, while the unclassified sample was one of the worst, if not the very worst, butters discovered in the whole forty-two exhibits examined.

The conditions producing these results seem to indicate bad dairy methods, and are certainly preventable. It is not our present purpose to discuss the probable reasons for such failures; but several creameries have evidently much to learn concerning the first principles of pasteurisation and cream-ripening.

CLASS 58.—"*Saltless Butter. 2 lb. made from fresh Cream.*"

A butter to merit a prize in this class ought to be fairly free from all bacterial contamination. It should be the product of clean, pure, sweet cream, made under the cleanest of clean conditions. Yet we actually find that a butter containing approximately the enormous number of 12,000,000 bacteria per *gram* is awarded a prize!

CLASS 59.—"*2 lb. Butter, salted with 1 oz. of salt to 6 lb.*"

One prize-sample contained an enormous number of very peculiar bacteria that formed dirty brown patches on gelatine and slowly putrefied curd of milk. In fact, the number present was so high that no attempts were made to even approximately estimate them. Mould-spores were also present in great numbers. One exhibit in this class was distinctly good from our present standpoint.

CLASS 60.—"*2 lb. Butter salted with 1 oz. salt to 6 lb., and made from fresh Cream.*"

One of the exhibits contained an enormous number of mould-spores, indicative of carelessness as to some source of contamination in the creamery.

Class 61.—"*2 lb. Butter salted with 1 oz. salt to 6 lb., and made from ripened Cream.*"

This class is only a slight variation on Class 57; and the remarks made under the latter class apply equally here.

One of the prize-butters contained approximately 260 mould-spores to the gram. This was such an extraordinary contamination that the analysis was done in duplicate, but with practically the same results. Still not satisfied, and fearing an error, the creamery was visited. The inside walls were found to be everywhere covered with fruiting moulds; so were many of the fixed appliances; and even the thermometer itself was covered with a white incrustation formed by the mould of sour milk. In another prize-sample in this class, the proper lactic-acid-forming germs were almost entirely suppressed by useless or objectionable forms. Both of these butters would speedily lose flavour. The other prize-butter was so heavily dosed with preservatives that all bacterial life was apparently destroyed.

Class 62.—"*Butter in packages suitable for parcel post.*"

One of the butters was treated with preservatives; and another contained in abundance a golden-yellow organism that gave a slight oily smell to sterilized milk on keeping it at room-temperature for ten days.

Selecting only those exhibits possessing very distinct characteristics, we bring them together in the form of a table for convenience of reference and comparison. Prize-butters only are here tabulated.

[Table II.

TABLE II.—ROYAL DUBLIN SOCIETY WINTER SHOW, BUTTER COMPETITION.

Summary of Prize Exhibits displaying very distinct characteristics. The figures represent the number of Exhibits in each Class, showing the special character indicated at top of column.

Butters that would rapidly deteriorate.	Butters that would slowly deteriorate.	Butters unfairly competing because of the use of preservatives.	Butters containing gas-forming organisms.	Butters containing mould-spores in large numbers.	Butters distinctly bacteriologically pure.	CLASSES.
1	—	—	—	—	—	53
1	—	--	1	—	1	54
—	1	1	—	—	—	55
1	1	—	—	—	—	56
2	—	—	—	—	—	57
1	—	—	1	—	1	58
1	—	—	—	1	1	59
—	—	—	—	1	—	60
2	—	1	—	1	—	61
—	1	1	—	1	1	62

The results given in this communication indicate only a small fraction of the work done in connexion with the investigation; but I hope sufficient evidence has been produced to demonstrate to the Society the extreme value of bacteriological tests in judging Show butters. As already stated, after having examined the butters, a round of visits was made to many of the contributing creameries, in order to compare Laboratory results with every-day conditions at the factories. We give in parallel columns the results found in a few typical cases; it is needless to give the full list.

TABLE III.—ROYAL DUBLIN SOCIETY SPRING SHOW, BUTTER COMPETITION.

Some Results of the Bacteriological Examinations of the Prize-Butters, compared with observations personally made at the contributing Creameries.

Laboratory letter for Creamery.	Bacteriological character of the Butter.	Observations made at the Creamery within 10 days after completion of bacteriological tests.
A	The predominant bacterium was one forming pink colonies. It grew in milk and coloured it, but was otherwise, apparently, harmless.	The inside walls of the creamery in places were covered with pink patches formed of this identical organism.
D	Highly contaminated with gas-forming and putrefactive germs, growing best at high temperatures.	Milk pasteurised at a temperature just high enough to destroy the lactic-acid-forming germs, but not high enough to kill the really harmful bacteria.
K	Badly contaminated with putrefactive and gas-forming organisms.	Butter made from pasteurised cream, but ripened in tanks so placed as to secure constant contamination by draughts from a dirty yard. Floor of creamery unclean.
G	Bacteriological evidence destroyed by use of preservatives. Suspicious.	Milk received in a partially sour state. A starter used, but impure. Creamery apparently clean.
M	Practically containing only lactic-acid-forming germs.	The milk is examined on delivery, and rejected if not satisfactory. The cream is pasteurised; a starter is used, and found to be pure. Creamery clean.

In conclusion, I take it that the object of the Society in these butter competitions is to promote and encourage the manufacture of the very highest grade of butter in Irish creameries. This can only be attained by those directly responsible for the supply of milk and the manufacture of butter recognising the extreme importance of unceasing watchfulness directed against contaminations associated with dirt. Good butter can only be produced under the strictest conditions as to cleanliness, and by Managers possessing an intelligent notion of the principles underlying the various processes adopted in modern dairy work. The outcome of such competitions ought to produce not merely a sample of butter specially prepared for the Show, but an all-round grading-up of the ordinary output of the creameries. So far as the real merit of a butter can be accurately determined and fairly compared with others of the same class, a bacteriological test seems to me to be by far the best method of judging, at least in Shows of such national importance as those held by the Royal Dublin Society.

EXPLANATION OF PLATES.

PLATE IV.

PLATE IV.

[All of the circular illustrations in this and the two following plates are photographic reproductions of cultivations in gelatine of bacteria, mould-spores, &c., found in the one-thousandth part of a gram of butter.]

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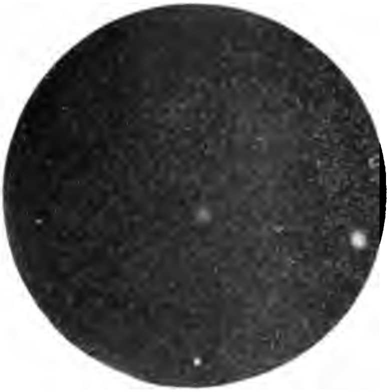
1. A cultivation made from a butter gaining a "second prize." The tiny specks represent growing colonies of lactic-acid-forming bacteria. The two small circular patches represent two moulds.

2. A cultivation from a sample of unsalted butter gaining a "first prize." It shows four colonies of denitrifying organisms, a mould, and a considerable number of opalescent bacterial colonies, in addition to an enormous number of smaller colonies not visible in this photographic reproduction.

3. A cultivation from a "first-class" slightly-salted butter, revealing a large number of contaminating bacteria. The predominant forms, however, were apparently of a harmless nature so far as the butter itself was concerned.

Plate IV.



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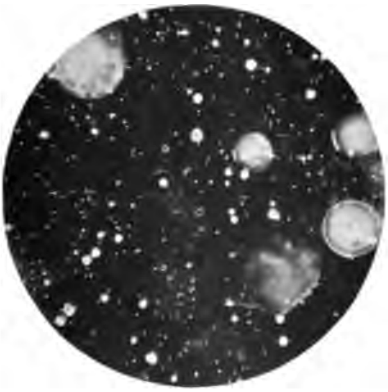

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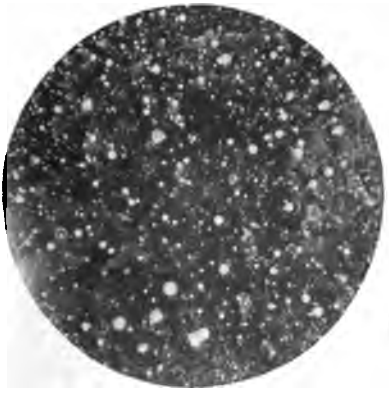

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EXPLANATION OF PLATES.

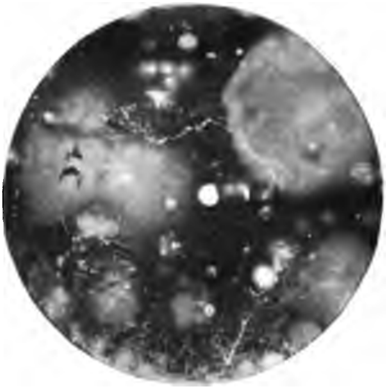
PLATE V.

PLATE V.

4. A cultivation of a "first-class" butter made from ripened cream, and may be taken as a type of a butter made from badly-ripened and much contaminated cream. There are no less than three kinds of mould present, while the proper cream-ripening bacteria are for the most part destroyed by the rank growth of bacterial weeds.

5. A cultivation from a "second-class" butter made also from ripened cream, but badly ripened as in the last case, and contaminated much in the same way.

6. A cultivation made from a sample of fresh butter taking a "third-class" prize. This may be accepted as a good specimen of a very badly contaminated and non-keeping butter. In it are shown a large number of gas-forming and putrefactive bacterial colonies indicative of much carelessness in the handling of the milk.



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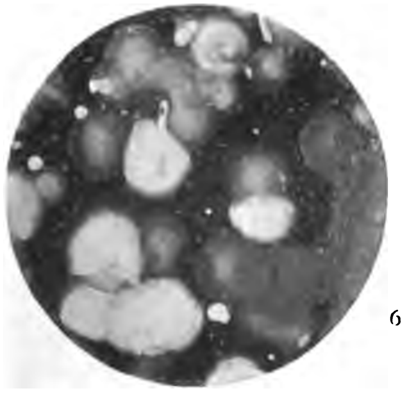

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Garratt & Atkinson.

EXPLANATION OF PLATES.

PLATE VI.

PLATE VI.

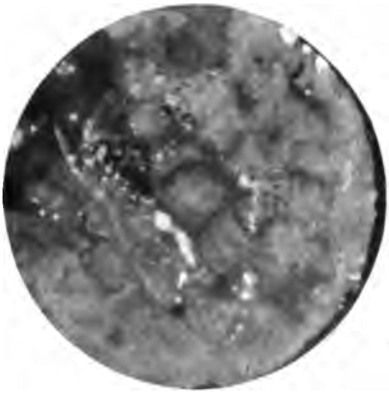
7. A cultivation from a "third-class" butter made from ripened cream, in which very peculiar micro-fungi developed. In about one week's time, most of the colonies, as is shown in the photograph, coalesced, and produced a delicate brown carpet over almost the entire surface of the culture-medium. It was subsequently discovered that the creamery building, previous to its present use, was used as a mill; and the character of the discovered contaminations seems to indicate careless or imperfect cleaning and disinfection before its conversion into a creamery.

8. A cultivation from a fresh-cream butter taking a "first prize." As here seen, it was speedily overrun with a large number of dung-moulds (a species of Mucor), suggesting an impure milk-supply.

9. Shows the result of a fermentation-experiment with buttermilk taken direct from the churn in a creamery where preservatives were used in making up the butter. A little of the buttermilk was added to a third of a test-tube of sterilised milk, and a thick layer of melted vaseline poured over the surface of the fluid. This was kept at blood-temperature for twenty-four hours or so, when the amount of gas generated was sufficient to lift and push out the vaseline plug.

10. Shows the result obtained by keeping a little of a certain creamery "starter" at blood-heat for twenty-four hours. The milk thickened; and a large number of cavities (formed by generated gas) arose in the curd.

11. Shows the result obtained by inoculating a tube of beef-jelly with a bacterium found abundantly in one of the "first-class" butters. The gelatine is half-digested or liquefied, and gives off a putrid aroma. This is the exact action that takes place when the albuminoids present in butter are attacked by putrefactive bacteria.



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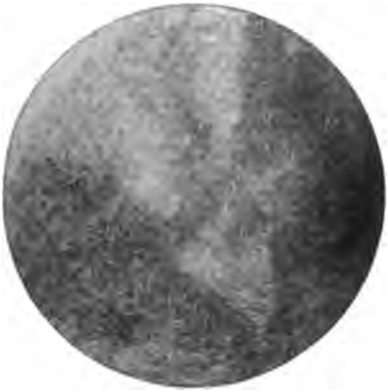

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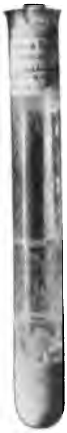

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IX.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1902. By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Consulting Entomologist to the Royal Dublin Society.

PLATES VII. AND VIII.

[Read FEBRUARY 17; Received for Publication, FEBRUARY 24;
Published, JUNE 25, 1903.]

CORN AND POTATO INSECTS.

Swift Moths.

Hepialus humuli, Linn.

IN April, caterpillars of Swift Moths were received from two correspondents in County Roscommon, with the complaint that they were proving destructive to potato-tubers and to the roots of oats. These insects are well known to be thus injurious; and though I have never before heard directly of their ravages in Ireland, there can be no doubt that they often cause serious loss to farmers, as all the five British species occur in this country; and the two most destructive of these, *H. humuli* and *H. lupulinus*, are common, especially the former.

The "Swifts" (*Hepialidae*) form a very distinct family of moths, of great interest to the student of insects, on account of the primitive nature of many of their characters. They are the only large moths in our fauna whose hind-wings, possessing five radial nervures, resemble the fore-wings closely in shape and neuration. In the vast majority of moths, the number of radial nervures in the hind-wing is reduced to one. A fold of membrane—the jugum—at the fore-wing base is another marked characteristic of this order, linking them with the lowest of the minute moths—the Eriocraniidæ and Micropterygidæ, and even with the Caddis-flies.

The "Ghost" Swift Moth (*Hepialus humuli*) is the largest of the family, and is named from the almost uniformly white wings of the male, which, when outspread, measure more than 40 mm. (1½ inches) across. The larger female has pale yellowish fore-wings with reddish markings, and reddish grey hind-wings (Plate VII., A). This moth is on the wing in summer evenings, and mostly during June and July. In both sexes, the jaws are reduced so that feeding is impossible in the perfect state. The white colour and a scent given out by the males serve to attract the females, so that pairing takes place without delay. When the female has laid her eggs, which she drops on the ground among grasses, &c., the parents die (1., pp. 165–8).

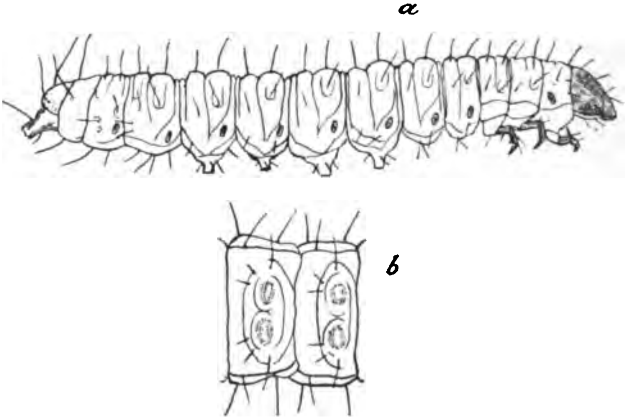

Fig. 1.—(*a*) Caterpillar of Ghost Swift Moth (*Hepialus humuli*); twice natural size; (*b*) third and fourth abdominal segments from beneath, to show pro-legs with complete circles of hooklets. × 3.

The caterpillar of *H. humuli* is, when fully grown, about 1½ inches in length. The head, and a plate on the foremost body segment are reddish brown, while the rest of the much-wrinkled body is dirty white or pinkish in colour. The air-holes or spiracles are black, and there are pairs of black dots along the back. The caterpillars of the Swift Moths may be known from all other large root-feeding caterpillars by the complete circles of hooklets on the abdominal pro-legs (fig. 1). The caterpillars, in the more highly-developed families of moths, have these hooklets only on the inner edge of their pro-legs. From July or August, when they are hatched from the eggs, the "Swift" caterpillars feed on through the winter, not becoming fully grown until the following May. As they are therefore largest in the springtime, they might be expected to be then more voracious than at other seasons. In May they turn to brown spiny pupæ, which rest in cocoons just below the surface of the ground. After about a month in this state, the pupa partly emerges from its cocoon; and the moth makes its way into the upper world (Plate VII., A).

Probably the most effectual way of destroying these caterpillars would be to place potatoes as traps a few inches below the surface in various parts of the attacked field, and to examine them periodically, collecting and destroying the contained insects. The caterpillars might also be turned up to fall a prey to pigs or birds. Gas-lime sometimes serves as an effectual dressing in such attacks.

Crane-flies.

Tipula oleracea, Linn., and other species.

In June I received, through the Editor of the *Farmer's Gazette*, specimens of the well-known "Leather-jacket" grubs of Crane-flies, which had been causing great injury to a crop of oats in County Down.

The Crane-flies or "Daddy-long-legs" are familiar insects, readily known by their slender bodies, very long and thin legs, and somewhat complex wing-neuration. The species of the genus *Tipula*—the commoner of which, mostly *T. oleracea* and *T. paludosa*, are alone of economic importance—are of considerable size, the largest insects indeed among our native Diptera. The hind-body of the female is long and tapering (fig. 2_3), provided at the tip with an ovipositor formed of several pointed processes. By means of this, she lays her eggs (fig. 2_4) in the ground usually in late summer or autumn. The grubs are dark, thick-skinned, wrinkled maggots, often known as "Leather-jackets" (fig. 2_1). The head is blunt and rounded, and the tail-segment has a toothed hinder edge. They have no legs; but, by means of series of bristles on their segments, they work their way through the soil, devouring roots greedily. After a life of some nine months, they pupate underground; and the pupa, when, after less than a month's rest, the time for its final change draws near, works its way out of the ground (fig. 2_2), its body-segments being provided with rows of short spines for this purpose, so that the fly may emerge into the upper air, the empty pupa-skin being left with its hinder half still buried.

Treatment for the attacks of these grubs, as given by Miss Ormerod (15, pp. 48–50; 16, pp. 96–7) aims at stimulating the crop and killing the insects by some appropriate dressing, and also at checking their migrations through the soil by mechanical means, such as rolling. As the grubs habitually burrow deeply during the day, and come near the surface at night, it is desirable to roll after dark or before dawn. The following mixtures are recommended for dressing infested land:—1½ cwt. guano, 2 cwt. salt, 1 cwt. kainit, and 1 cwt. superphosphate per acre; or 3 cwt. salt and 1 cwt. soda nitrate per acre. A Scotch correspondent of Miss Ormerod states that scattering cheap rape-cake over an infected field was a very effectual remedy; the grubs devoured the cake greedily and it killed them. This practice has been recommended, without foundation in fact, for Wireworm attack. It has often been remarked that the attacks of these grubs are specially bad on crops sown on recently broken-up pasture, and much in the way

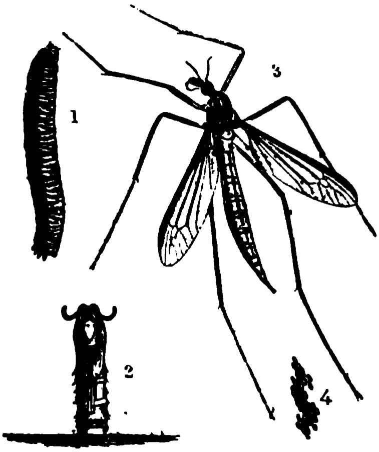

Fig. 2.—Crane-fly (*Tipula oleracea*, L.). 1, Larva; 2, Pupa skin standing up in the ground; 3, Female Fly; 4, Eggs; natural size. From Ormerod's "Reports" after Curtis.

of prevention may be done in autumn. "Such measures," writes Miss Ormerod, "as rough mowing and burning the rubbish, brush-harrowing, hand-feeding sheep on the land to be broken up, or strong dressings of chemicals . . . are examples of various kinds of serviceable protective treatment."

These crane-fly grubs, which are always abundant in moist soil, are probably among the most serious of the Irish farmers' commoner insect-enemies. It might be well worth while, in summer-time, when the flies may often be seen skimming over the grass-lands in hundreds or thousands, to take some trouble to collect and kill them.

The Wheat Bulb-Fly.

Hylemyia coarctata, Fall.

Specimens of young wheat plants very badly injured by the maggots of this fly were received in April from a farm at Loughlinstown, County Dublin. According to the information given, seven acres of wheat had been destroyed by the insects. The crop thus ruined had been sown in January, the land having been last used for potatoes. After the destruction of the young wheat plants, the field was re-ploughed in preparation for an oat-crop.

This fly belongs to the same family (Anthomyidæ) as the Cabbage-root flies described in my paper (5) of last year. This family is closely allied to the Muscidæ (common house-fly, blue-bottles, &c.), but may be distinguished by the wing-neuration, as the fourth longitudinal nervure runs almost parallel to the third; whereas, in the Muscidæ, this nervure bends up towards the third at a marked angle. According to Meade (10), the genus Hylemyia may be distinguished by the feathered bristle of the feelers, the eyes (devoid of hairs) touching each other, or almost so, in the male, by the two small scales at the base of each wing equal in size, the elongate abdomen with tufts of hair beneath, and the anal nervure prolonged to the edge of the wing. From the other twenty odd species of Hylemyia found in the British Isles, *H. coarctata* may be distinguished by the exceptionally long hairs of the antennal bristle; the grey indistinctly-striped thorax; the narrow grey hairy abdomen, the yellow nervures of the wings, and the pale shins of the legs. In the female the middle and hind thighs are also pale; and the body of the fly is almost uniformly grey in colour. It is about 6 mm. (¼ inch) in length (fig. 3, *a*)

The white fleshy maggot (fig. 3, *b*, *c*) is 7 mm. long. The fan-shaped fore-body spiracle (fig. 3, *d*) has nine divisions. At the tail-end, two bifid processes are conspicuous (fig. 3, *e*); in the present species these are much more prominent than in the allied Cabbage-root maggot (*Phorbia brassicæ*). These maggots feed within the stems of the young wheat, eating out the central tissue, and causing the decay and death of the plants (Plate VII., B). According to Miss Ormerod's observations (13, pp. 35–41; 14, pp. 31–39), the maggots are first observed in February or March. In May or June, they pupate either within the injured stalks or in the neighbouring soil; and the flies appear in June or July. Nothing further regarding the life-history in Great Britain seems to be known with certainty; but on the Continent the maggots of the midsummer flies are said to feed in the corn-crops during the summer, and the flies that develop from them lay their eggs on the sprouting winter corn,

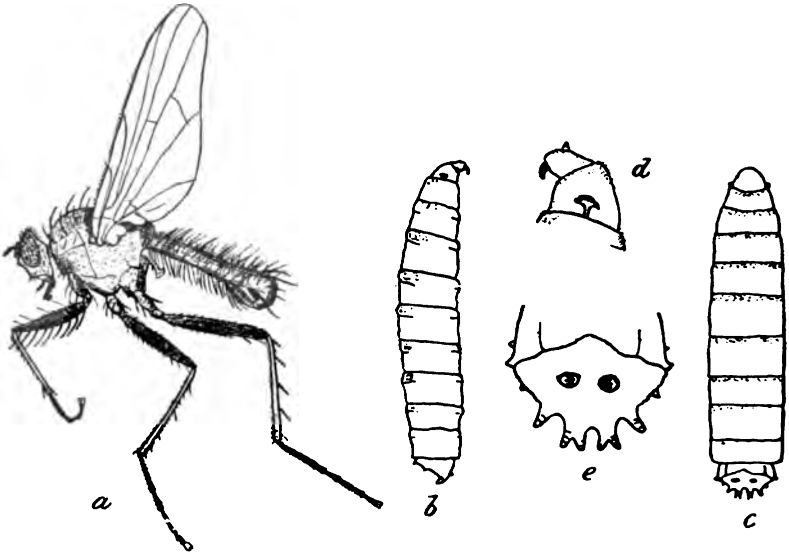

Fig. 3.—Wheat-Bulb Fly (*Hylemyia coarctata*, Fall). (*a*) Male fly: × 6. (*b*) Maggot, side view. (*c*) Maggot, upper view: × 6. (*d*) Head-region of maggot, showing mouth-hook and fore-body spiracle: × 16. (*e*) Tail-region of maggot, showing spiracles: × 16.

giving rise to the destructive early-spring brood of maggots (2, p. 613).

From information supplied by Miss Ormerod's correspondents, it seems clear that this insect is most destructive to wheat after the land has been fallow in the previous summer. Damage was also often noticed when wheat followed potatoes (as in the present case) or swedes, but not when wheat followed white turnips, mangolds, or beans. Oats and barley are not attacked by this insect. These observations give some practical guidance to farmers as to how the attack may be prevented. It is hoped that observations on the habits of the second generation of maggots and flies may be made shortly. The suggestion put forward by Miss Ormerod (14), that there is no second brood, but that the summer fly lays her eggs in the bare ground in waiting for the winter-sown wheat to sprout, cannot be entertained. Knowledge of the life-history of the second generation would give us a sure means of preventing the insect's ravages, which seem often to be serious. The internal feeding-habit of the maggot renders any of the ordinary remedial measures unavailable, except the obvious manuring of a crop to enable it to survive the attack. It is almost needless to add that where a ruined crop has to be ploughed in, the plants with their contained maggots should be buried deeply.

ROOT AND GREEN CROP INSECTS, &c.

The Carrot Fly.

Psila rosæ, Fab.

In July I received from the Rev. P. O'Driscoll, of Inchigeela, County Cork, carrots injured by the maggots of this well-known insect. It was stated that in 1901 carrots were similarly affected in that locality, although in 1900 the crop had been uninjured. In 1896 I gave a rather full account of this fly, and discussed the means for its destruction (4).

THE MANGOLD FLY.

Pegomyia betæ (Curtis).

Through the kindness of Mr. E. Gallagher, Editor of the *Farmer's Gazette,* I received, in June, leaves of mangold from

County Carlow, ruined by the maggots of *Pegomyia betæ*. Mr. Gallagher informed me that the insect had been unusually active during the summer, and had done damage in other parts of Ireland. This fly is worthy of attention, for, in addition to its direct injury to the plants, it possibly renders them especially liable to attack by the Rot-fungus (*Phoma betæ*). Reference to this insect will be found in my paper of last year (5).

White Ringed-Worms.

Enchytræus parvulus, Friend, and other species.

In 1897 Rev. H. Friend (7) called attention to the damage done by small white annelids to various garden-plants. These worms had not been previously regarded as injurious. It is of some interest therefore to record that during the past year they have been observed in several parts of Ireland attacking several kinds of plants.

Roots of celery and cabbage from a County Dublin garden were sent in January, 1902. The roots and the bases of the stems were bored and tunnelled by the worms; and the result of their ravages was to reduce the plants to a slimy, evil-smelling, and decaying mass. Many of the worms were observed to be at work on almost fresh tissue. As these creatures have no kind of biting jaws, it must be supposed that they soften the tissues by some secretion before they begin to tunnel. I was informed that "every vegetable in the garden" was affected in the same way.

Through the *Farmer's Gazette*, I received in May from Crannogael, County Armagh, tomatoes injured by Enchytræids. And in November, swedes, very badly damaged, were sent to the Department of Agriculture from County Sligo. In the last case, the "Finger-and-toe" slime-fungus was also present; but, according to the farmer's observations, the worms had appeared before the "Finger-and-toe."

Mr. Friend was kind enough to examine specimens of these worms for me; and he has published (8) a short account of those attacking celery, drawing attention to the fact that the small white worm, only 3–5 mm. (⅛–⅕ inch) long, which he named *Enchytræus parvulus*, is followed and superseded by a larger form.

He suggests that there may be some genetic connexion between the two. The worms from County Sligo injuring swedes are referred by him to a species of *Henlea.*

These worms are liable to be mistaken for the well-known "eel-worms" (*Tylenchus*) which attack oats and clover. The Enchytræids may be easily distinguished by their larger size, and the distinct segmentation of the body. As in the related earthworms, most of the segments carry four series of bristles, which enable the animals to move. It is likely that the application of sulphate of ammonia, which, at the rate of 1 cwt. per acre, is sometimes effectual in destroying eel-worms, might prove a valuable remedy also against these destructive annelids. I have been informed, by the courtesy of Mr. J. J. Egan, that the County Dublin garden mentioned above was almost cleared of the worms by a very heavy dressing (1 ton to the acre) of rough agricultural salt.

GARDEN AND GREENHOUSE INSECTS, &c.

The Rose Sawfly.

Eriocampoides æthiops (Fab.) (= *Eriocampa rosæ*, Cameron).

Rose-leaves injured by the grubs of this well-known sawfly were sent in July by Sir J. F. Dillon, of Lismullen, County Meath. The insect is about 4 mm. ($\frac{1}{6}$ inch) long; the body is black and shining, as are the hind-legs and the thighs of the front and middle pairs of legs, the shins and feet in the latter being white. Eggs are laid in May on the midribs of the leaves; and the caterpillars, pale yellowish-green, with orange head, feed through the summer, eating away the upper skin and central green tissue of the leaf, and often doing great damage (3, pp. 227–8). They pupate in oval cocoons that may be found underground in winter. The method of feeding adopted by this caterpillar closely resembles that of the "Slugworm" of the allied Pear-sawfly (*E. limacina*, Scop.). Syringing the foliage with paraffin emulsion or Paris-green mixture would probably be effectual in destroying them.

Woodlice.

Oniscus asellus, L. and *Porcellio scaber*, Latr.

Of the sixteen species of air-breathing Isopod Crustaceans, commonly known as Wood-lice or "Slaters," that are found in Ireland (18), the two mentioned above are the commonest and most destructive. In gardens and greenhouses they are often greater pests than any true insect. Lurking beneath stones, and tiles, and flower-pots in the day-time, they gnaw constantly at roots; while, at night, they sally forth and eat up the tender green shoots. During the year I had several complaints from various localities about these creatures. The best means for destroying them seems to be to set a trap consisting of a hollowed-out potato. Into this they crowd in large numbers; and they may be readily collected and killed by means of boiling water.

A New Fern-eating Weevil.

Syagrius intrudens, Waterh.

Early last year, Mr. F. W. Moore sent me specimens of a weevil that had been causing the greatest damage in the fern-houses at the Royal Botanic Gardens, Glasnevin. He writes:—"The mature insect eats the fronds; and the larva devours under the soil, burrowing through the leaf-stalks and rhizomes, completely eating away the centre and killing the plant."

A glance at the large weevil showed it to be some introduced exotic species; and as it was quite unrepresented in the Dublin Museum collection, I sent specimens to Mr. C. O. Waterhouse, of the British Museum. He recognised it as belonging to the Australian genus Syagrius; but he informed me that it must be referred to a new species. In subsequent correspondence with Mr. A. M. Lea, of Hobart, he learned that a nearly allied species, *S. fulvitarsis*, Pascoe, is a great pest in greenhouses at Sydney, destroying ferns, especially Adiantum and allied genera, by working up the stems from the roots. Mr. Waterhouse has now (19) described the insect under the name of *Syagrius intrudens.* His diagnosis of the species is as follows:—

"Elongatus, crassus, subparallelus, piceo-niger, parum nitidus, rugosus; antennis tarsisque piceis.

Long. 7–10 mm. [¼–⅜ inch.]

"Rostrum gently arcuate, thick, with a fine median smooth line and with a groove on each side above the antennal groove;

the apex shining and finely punctured. Forehead rugosely punctured, with a well-marked impression in the middle. Thorax with its broadest part in front of the middle, a trifle narrower at the anterior angles than at the posterior; the sides arcuate; the base exactly fitting the base of the elytra, but a trifle narrower. The surface very uneven, consisting of closely placed irregular obtuse tubercles, some of which are shining. The interspaces with very short brownish pubescence. Elytra very convex, humped up at the suture, with a slight constriction at the base, gradually widening from this to the apical declivity, where they are as wide as the widest part of the thorax. Apical declivity almost vertical. The region of the scutellum and some irregular, rather oblique, vermiculate impressions dull black. The rest of the surface covered with very irregular more or less confluent tubercles, which are themselves ornamented with very small shining tubercles. Near the suture, just at the apical declivity, there are two tubercles which are rather more prominent than the others; these, and some of the others, have more or less brownish hair on them. There are also some of these short brown hairs just within the humeral angle. At the sides there are two or three rows of elongate deep foveæ.

"The punctuation of the basal portion of the rostrum varies very much. Some specimens have it closely and rugosely punctured; in others the punctures are separated, and the surface is shining. This difference is no doubt sexual.

"This species resembles *S. fulvitarsis*, Pascoe (Ann. & Mag. Nat. Hist., xvi. 1875, p. 56), but the rostrum is less strongly curved, and the tubercles on the dorsal surface of the thorax and elytra are much more numerous. In *S. fulvitarsis*, the dull black surface is greater than that occupied by the tubercles; in *S. intrudens*, the reverse is the case."

The larva of this insect (fig. 4 *c*) is, like that of most Curculionidæ, legless, white and fleshy, with wrinkled skin and strong rounded brown head. The body is more elongated and the skin less wrinkled than in the familiar grubs of our native Otiorrhynchi. The length of the larva of Syagrius is about 12 mm. (½ inch). I have sketched the weevil in profile and in dorsal view (fig. 4 *a*, *b*).

Mr. F. W. Moore has very kindly favoured me with the following account of the ravages of this insect, and the means that he adopted for getting rid of it:—

"It does damage in two ways—I. The mature insect eats the young fronds. II. The larvæ burrow inside the stems of the fronds, eating the soft central portion, there being no indication of their presence until the frond collapses, or they burrow inside the stems and rhizomes, killing the whole plant. The eggs are apparently laid in the stems or in the rhizomes, as there is a very minute puncture where the grubs are at work.

"Various methods to destroy them were tried. Fumigating with tobacco-juice or tobacco-paper had no effect.

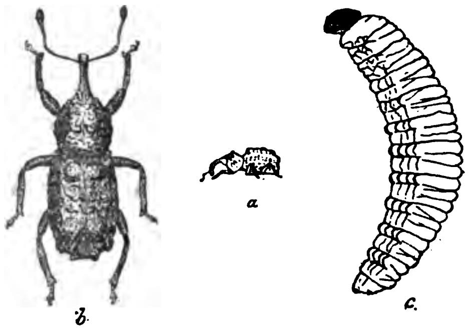

Fig. 4.—(*a*) *Syagrius intrudens*, Waterh., profile, natural size. (*b*) Dorsal view of Weevil: × 3. (*c*) Larva: × 3.

"An attempt was made to poison them with cyanide of potassium, watering with a solution of 3 grs. to 6 oz., and then washing out with clean water. This killed the grub, but also killed the plants. A weaker solution did not kill the grub. The plants were then shaken out, all soil picked away with a pointed stick, and burnt. Of course the plants suffered a lot; but they recovered; and a large number of weevils, grubs, and pupæ were got and destroyed.

"The weevil feeds at night; so the house was fumigated at monthly intervals at night, with 3 oz. cyanide of potassium, 5 oz. sulphuric acid, 15 oz. water to every 1,000 cubic feet. The water and acid were mixed in an earthen vessel, and the cyanide of potassium hung over it in tissue paper. At a fixed hour, the cords were loosened, and the cyanide allowed to drop into the vessel. This is a very deadly poison, and must be used with the greatest care. No one must enter the house for hours after it has been used. Finally all the plants were steeped in a vessel of water, the surface of the pots being one inch under water. The weevils crawled out, and were hand-picked as they crawled up the stems. This was the most effectual method; and after eighteen months' constant work, the weevil has been partially exterminated in all the houses. It is the most destructive garden-pest I have ever met with."

FOREST INSECTS.

Woolly Scales of the Beech.

Cryptococcus fagi, Barensp.

In March I received from Mr. J. W. Warburton, of Rostrevor, pieces of beech bark, covered with multitudes of cottony scale-insects, or "mealy bugs." Mr. R. Newstead, of the Grosvenor Museum, Chester, to whom I sent specimens, kindly determined them as *Cryptococcus fagi*, Barensp. The waxy secretion of the females of these insects forms white, felted threads which serve as a protection for the eggs and developed young. No firm, hard "scale" is formed as in the mussel-scale of the apple, and most other well-known insects of this family. Mr. F. W. Burbidge has shown me a curious fact with reference to this insect. At the Botanic Gardens of Dublin University there is a weeping beech grafted on to a common beech stock. The bark of the stock is always more or less affected by the Cryptococcus; but it is hardly to be found at all above the graft line.

Where this or similar insects congregate on the bark of trees in such numbers as to threaten injury, it is probable that washing with paraffin emulsion will be found the safest and most effectual remedy.

STORE AND HOUSEHOLD INSECTS, &c.

Hay-Mites.

Tyroglyphus longior, Gervais.

Multitudes of mites in hayricks, the creatures becoming so numerous that they fall in masses on to the ground, are probably familiar objects to many farmers, especially in the south and west. These mites occur not only in hayricks, but, according to Miss

Ormerod's observations, also in stacked oats and clover. The species, *Tyroglyphus longior*, is characterised by the great length of the hair at the hinder end of the body (fig. 5). It is often found in cheese along with the species, *T. siro*, usually known as the "cheese-mite," which has a more rotund body, and shorter hairs. It is believed that a few of these mites are brought in from the field with the hay, and that they find in the rick such conditions of warmth and moisture as stimulate their excessive multiplication. It is often noticed that they are most numerous in imperfectly "saved" hay. There is a general belief that it does no harm to horses or cattle to swallow a few hundred of these mites. But when they drop in masses out of a rick or stack, it might be at least worth while to collect and destroy them.

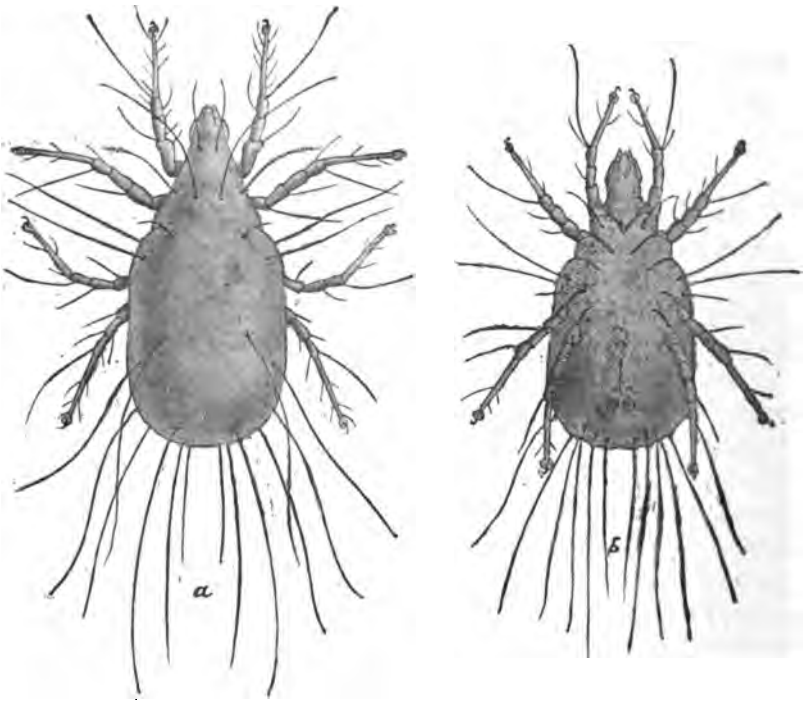

Fig. 5.—Hay-Mite (*Tyroglyphus longior*, Gerv.). (*a*) Male. (*b*) Female: highly magnified. From Howard and Marlatt (after Canestrini), Bull. 4 (N.S.), U.S. Dept. Agr. (Div. Ent.).

The Mediterranean Flour-Moth.

Ephestia kühniella, Zell.

For several years past I have heard of an insect causing great trouble in certain Belfast flour-mills. From the descriptions given me I had little doubt that the Mediterranean Flour-Moth was the offender. And now specimens received through the kindness of my friend, Mr. R. Welch, have set all doubt at rest, so that I have, with the sincerest regret, to add *Ephestia kühniella* to the list of our recorded Irish Lepidoptera.

The history of this insect is of quite exceptional interest. It was never observed certainly until 1877, when it appeared in a mill at Halle, Germany; and Zeller gave an account of its habits, describing the moth as a new species in 1879. But, according to the inquiries of Danysz, it had been known to practical millers in France as early as 1840; while Johnson (9), to whose paper I am greatly indebted, believes that he has evidence of its occurrence at Kiel in 1858. In 1884 the insect was observed in Belgium and in the lower Rhine country; in 1885 in Holland, and in 1887 in England. Its first appearance in our islands was in certain mills and stores at the east end of London. Miss Ormerod referred to it in 1888 (12) and in several subsequent reports. All Continental entomologists who had so far studied the moth believed it to be an importation from America. Nothing, however, was known of the presence of the insect as an economic pest in America until 1889, when it appeared in a mill in Ontario, Canada (17). In 1892 it was found near both the Atlantic and Pacific seaboards of the United States. But specimens from Alabama were in the National Museum Collection at Washington before 1889; and, according to Danysz, its presence in America can be traced back to 1880 at least. There seems, however, no evidence for the belief that it was imported from across the Atlantic into Europe, as it was known in France and Germany long before it became a pest in America. A clue to its native country has been found in the fact that the first outbreak in London was traced to flour from Trieste and Fiume. Hence it has been inferred that the Mediterranean region was probably its centre of dispersal. But Johnson (9) states that in California it has been found in the nests of Humble-bees. This fact makes it likely that the species is, in reality, native in both Europe and America, and that it was exceedingly scarce until it took to living in flour as an "unbidden guest" of man, thus finding new and highly favourable conditions of life, so as to force itself on our attention. It is certain that it can be very readily spread from centre to centre by commercial intercourse. As mentioned above, it was in London in 1889. In 1891 Miss Ormerod recorded it from Cheshire, Yorkshire, and North Wales. Meyrick, in 1895 (11), stated that it ranges northwards to Aberdeen; and it has evidently been established in the North of Ireland for three years[1] at least, being now common in several Belfast mills.

Ephestia kühniella, a small moth measuring about 12 mm. (½ inch) long, and 20 mm. (⅞ inch) in wing-spread, belongs to the family Pyralidæ, and falls into the sub-family Phycitinæ. The genus is characterised by the presence of only three radial and two median nervures (fig. 6, *g*, *m*, *r*) in the fore-wing (many other Phycitinæ have four radials and three medians, and most Pyralidæ five radials and three medians, respectively), and by the upturned palps in front of the head.

The moths of this genus have two characteristic transverse lines on each fore-wing, called, starting from the root of the wing, the first and second. In *E. kühniella*, the first line is indented in the middle and bends obliquely outward at the inner edge, while the second line is indented near the costa; the hind-wings are whitish (fig. 6, *a*, *f*). In the allied *E. elutella*, Hub., also a storehouse insect, the hind-wings are dusky (11).

The female moths wait the approach of the males in the characteristic attitude shown in fig. 6, *b*, with the tip of the hind-body projecting between the closed wings. They may often be found sitting on the whitewashed walls of infested mills. The eggs are laid by night, usually singly, but sometimes in chains of eight or ten. A female produces on the average about 200 eggs; and she places them in the spouts and elevators of the mill, among the flour stored in sacks, or in any other place where there is a food-supply for the caterpillars. She takes five or six days to lay all her eggs, and after this task has been accomplished lives for only two or three days longer.

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[1] I am informed that some of the Belfast millers were in correspondence with the late Miss Ormerod on the subject in 1899.

The time between the laying of the eggs and the hatching-out of the caterpillars varies with temperature and other conditions; but from eight to nine days is a very usual period. The caterpillar when first hatched is only about 1 mm. ($\frac{1}{25}$ inch) in length. According to the temperature and the nature of its food, it becomes fully grown (13 mm., or ½ inch) in from five to six weeks. According to Fletcher's observations, the caterpillars took three months to become fully grown in the cold Canadian winter. The caterpillar is of a pale colour, whitish to pinkish, with reddish brown head and fore-body shield, and pale legs and pro-legs (fig. 6, *c*). Each segment carries six bristles on dark wart-like prominences (fig. 6, *e*). During their feeding period, the caterpillars become exceedingly troublesome and injurious. As they wander about the flour in mill or store, they drag after them fine threads of silk, and the result is that when many caterpillars are feeding, the whole mass of flour becomes matted together as if by a gigantic cobweb (Plate VIII.). According to Johnson, the caterpillars prefer buckwheat or oatmeal to wheat-flour. When ready to pupate, the caterpillars become very restless, and usually wander to out-of-the-

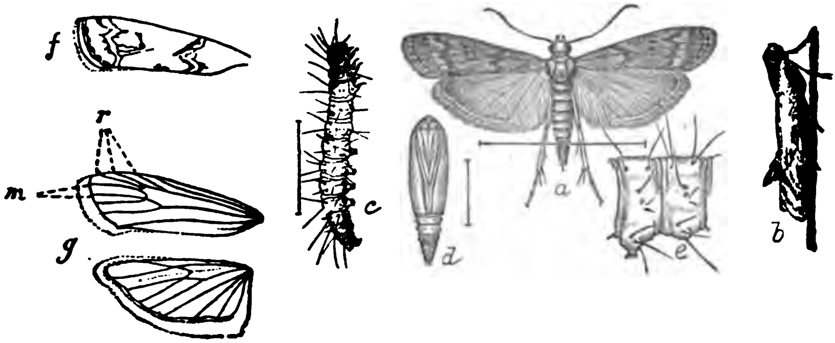

Fig. 6.—Mediterranean Flour-Moth (*Ephestia kühniella*). (*a*) Moth flying; (*b*) at rest; (*c*) Caterpillar; (*d*) Pupa: all twice natural size. (*e*) Segments of Caterpillar: more highly magnified. (*f*) Markings of fore-wing in outline. (*g*) Wing-neuration. (*r* radial nervures; *m* median nervures): twice natural size. From Riley, Howard, and Chittenden. *Insect Life*, vol. 2, and *Yearbook*, 1894. U.S. Dept. Agr.

way corners of the building that they inhabit. There they make cocoons by spinning a silken meshwork mixed with particles of flour and other foreign material. Thus sheltered, the caterpillar changes to a reddish-brown pupa (fig. 6, *d*), darker on the head, fore-body, and tail-segment (which bears nine or ten bristles to hold the pupa in the cocoon), and paler on the wings and hind-body. The pupal stage lasts about a fortnight. The empty pupa-skin remains within the cocoon when the moth makes its way out (9).

It is in the spouts and elevators of the mills that the greatest annoyance and loss are caused by these caterpillars. There they may feed away unseen until the effect of their web-spinning has matted together great masses of flour, so as to stop the machinery. In this way the work of the miller is hindered, and tons of flour are ruined. Mills in which the moth establishes itself often have to be closed for months at a time while the plant is thoroughly cleaned and overhauled. The risk of the loss to which millers may be put by this insect should incite all to be on guard, and to take precautions to keep so undesirable a visitor off their premises.

The transport of the insect from one place to another is effected mostly during the egg and larval stages; and empty sacks and barrels, and secondhand machinery, have been often the means of effecting its introduction. Among the small quantity of flour adhering to an empty sack several eggs or caterpillars may be hidden; and the insect may thus become established in a new mill. It should, at least, be possible to subject all in-coming material, from infested or suspected districts, to thorough examination, and baking, steaming, or fumigation. And it is evident that the more scrupulous the cleanliness in which a mill is kept the less chance will there be for the flour-moth to establish itself there. It is found in American practice that metal spouts afford far less harbourage for the insects than do wooden ones. Mr. Welch tells me that a large Belfast mill, after having been renovated with new floors and fittings, was shortly invaded by the moth, and became as badly infested as before.

If, through carelessness or unavoidable misfortune, a mill should become inhabited by these moths, the most persistent efforts will be needed to get rid of them. Frequently sweeping and dusting the premises, elevators, and machinery, is an obvious remedy ; and good effects have followed, in America, from the use of an elevator-brush, consisting of a flat square board, bearing bristles on three sides, and fixed by the fourth at right angles to the surface of the elevator belt. The bristles must be of such a length that their tips sweep the corners and sides of the elevator as the belt moves. But mechanical measures are rarely sufficient to clear away the insects. Three agencies have been found most effectual ; these are steam, sulphur, and carbon bisulphide.

For cleansing purposes, it has been recommended that a steam-pipe, with cocks at intervals of every twenty feet, might be laid along every floor of a mill. By attaching a hose, with a nozzle, to one of these cocks, a jet of steam can be directed to any part where refuse has accumulated, or along any flour-channels that may be infested with caterpillars. This plan is adopted in many American mills, and such a "steam-sweeper" is obviously preferable to filling the whole building with steam direct from a boiler, and thereby causing rust and encouraging mould. Scalding steam is fatal to the insect in all its stages.

Fumigation with sulphur has been, in addition to steaming, the favourite way of fighting the insect in England (12, 13, 14). Sulphur and saltpetre, in the proportion of 3 lb. of the former and 3 oz. of the latter to every 1000 cubic feet of air-space, are placed in a bed of ashes in a metal pan and ignited. The usual practice is to start such fumigation on a Saturday afternoon, and then to leave the building closely shut up until Monday morning, so that the fumes may penetrate to every corner. Thorough ventilation after fumigation is essential ; and, as the sulphur fumes often act injuriously on the gluten in the flour, all stock should be cleared out as far as possible.

American entomologists and millers prefer carbon bisulphide to any other agent for destroying the moths. This is an evil-smelling inflammable liquid, whose vapour is highly poisonous, and, when mixed with air, explosive. It is placed about the mill in shallow vessels, or on soaked "waste" in the elevators and spouts. For every 1000 cubic feet of air-space in a building 1 lb. of the bisulphide is required if the place can be shut up tightly. As with the sulphur fumigation, the work is done on Saturday afternoons; and the building must be very well aired before the mill is started (especial care is needed in lighting fires after fumigating with the bisulphide) on Monday morning. This compound must, of course, be used *with great care*; and practical men in these countries are inclined to avoid it. But the American workers prefer it because, unlike steam or sulphur, it is quite harmless to the flour or other food-stuffs stored in the fumigated mill (9).

Mr. Welch tells me that in Belfast carbon bisulphide has been freely used in some cases, and that the moths about the mill have been killed by its fumes; but that it did not destroy the caterpillars feeding in the spouts, nor kill the eggs. Frequent cleaning of the whole building and machinery serves to keep the insect in subjection, the masses of spun-up flour being burned in the boiler furnaces. But any lack of watchfulness would entail the rapid multiplication of the insects again. Apparently, in Belfast, sulphur has been more successful than carbon bisulphide. Mr. Welch writes:—"A miller, in a large way here, has cured the trouble thus: all ventilators, windows, &c., are closed, and all spouts, machinery, rooms, &c., opened up free from bottom to the top of the mill on a Saturday, when work ceases for the week; then sulphur is burned on the ground-floor, and the fumes go right up and have access to every hole and corner in the whole mill and machinery; the latter has all to be oiled, for protection from the sulphurous fumes, which even then do some damage to the iron- and brass-work. The silk-gauze is certainly damaged also by the fumes; but the miller thinks the gain more than worth the trouble. He has so thoroughly exterminated them that the insects have only re-appeared three or four times, and on each occasion the same plan has been effective."

It has been suggested to me that formalin might prove a safe and effectual substance for fumigation. It would at least be worth while to try its effect on a small scale.

Wood-boring Beetle.

Anobium domesticum, Fourc.

Wooden objects bored by this and other allied species are constantly brought to notice in old houses. These beetles are among the most familiar of injurious insects; and their presence is indicated by the ‘shot-hole’-like borings in the wood they inhabit. Plunging the infested articles into boiling water, or drenching with benzoline or naphtha, may usually be relied upon to destroy them.

The Biscuit Beetle.

Anobium paniceum, Linn.

From Mr. J. Stewart, of Limerick, I have received coriander fruits with the whole seed eaten out by the larva of this beetle—a white, fleshy, wrinkled grub, with brown, hard head and three pairs of fairly well-developed legs. This insect is most omnivorous in its tastes. The Americans know it as the "drug-store" beetle; and it seems to thrive on all kinds of medicinal substances, even such a narcotic as opium, or poisons like aconite and belladonna, as well as on old books, papers, and compressed meat, boots, cork, and even tin-foil and sheet-lead. (See fig. 7.)

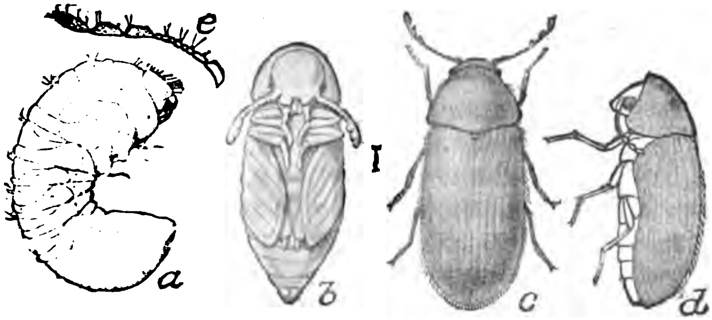

Fig. 7.—Biscuit-beetle (*Anobium paniceum*); (*a*) Grub; (*b*) Pupa; (*c* and *d*) upper and side views of Beetle: all × 10. (*e*) Feeler of beetle: × 25. From Chittenden, Bull. 4 (N.S.), U.S. Dept. Agric. (Div. Ent.).

Anobium paniceum resemble *A. domesticum* in its general cylindrical form and retracted head, but differs from that and other species in having hairy eyes and feelers with the second segment twice as long as the third (fig. 7, *e*). On this account it is placed by some naturalists in a distinct genus—*Sitodrepa*.

Mr. Stewart had imported the infested fruit from London. The beetles were breeding there; and it seems that the larva, when quite young, bores its way through the envelope of the fruit, and finds congenial shelter and food within. Happily this insect is so far rather uncommon in Ireland, being recorded only from Dublin, Louth, and Waterford.

The possible spread of such a species, still more of the Mediterranean flour-moth described above, should incite all owners of mills, stores, or any building that may harbour such pests, to be constantly watchful against their importation, which may at all times happen in unnoticed ways.

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EXPLANATION OF PLATE VII.

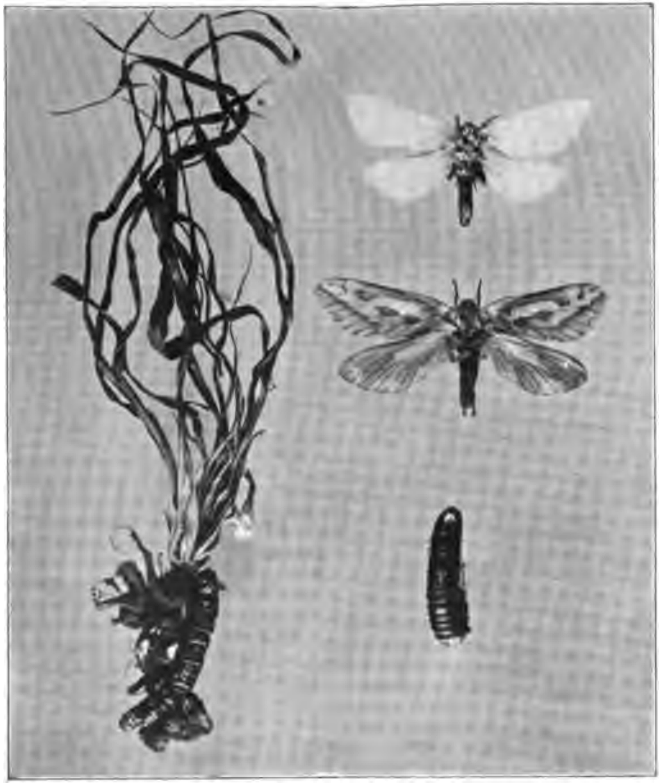
PLATE VII.

A. Ghost Swift Moth (*Hepialus humili*, L.). To the left, Caterpillar feeding on roots of wheat; to the right, Male moth (above), Female, and Pupa. Two-thirds natural size.

B. Young Wheat Plant injured by maggot of the Wheat-bulb Fly (*Hylemyia coarctata*, Fall.). The sheathing leaves have been separated at the base to show position of maggot feeding within.

[The illustrations in these Plates are from photographs by A. Price.]

Plate VII.



A.

B.

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EXPLANATION OF PLATE VIII.

PLATE VIII.

Mass of Flour matted by the caterpillars of *Ephestia kühniella*, Zell. A caterpillar is seen towards the centre, and a moth towards the upper part of the figure. Two-thirds natural size.

[The illustrations in these Plates are from photographs by A. Price.]

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X.

MECHANICAL ANALYSES OF SOILS AND SUBSOILS BY CENTRIFUGAL ACTION; WITH NOTES ON TREATMENT OF SAMPLES.

By J. R. KILROE, of H. M. Geological Survey of Ireland.

[COMMUNICATED BY PROF. G. A. J. COLE, M.R.I.A., F.G.S.]

[Read, January 19; Received for Publication, January 22; Published, March 29, 1904.]

The extremely tedious nature of the processes commonly in vogue for separating sands, silts, and clays, in the mechanical analyses of soils and subsoils, by washing and decantations, has necessitated resort to more expeditious processes. Such means are absolutely necessary when many samples have to be treated in a limited time. The application of centrifugal force was suggested by Hopkins;[1] and, following up the suggestion, Prof. Milton Whitney, Chief of the Bureau of Soils in the United States Agricultural Department, has devised an apparatus, worked by an electric motor, by means of which separations are at present carried out, very expeditiously, and with a fair degree of precision.

The principle of the method is that now utilised for emphasising the difference in hydraulic values between the heavier and lighter particles in fluid mixtures, which finds illustration in the various kinds of milk separators, or in those used in the estimation of butter fat.

In Whitney's apparatus,[2] four test-tubes are freely suspended, one at each extremity of four arms spreading outward from a central axis; as the axis revolves, the lower ends of the tubes fly outward, with a force dependent upon the velocity. The tubes are one inch in diameter and seven in length; and in them are placed aqueous mixtures of the earths to be analysed, prepared by being boiled in water and thoroughly shaken, for perfect detachment of the clay particles from the sand and silt.

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[1] Proceedings of the Fifteenth Annual Convention of the Association of Official Agricultural Chemists. Bulletin 56, Division of Chemistry, United States Agricultural Department, 1898, p. 67.

[2] Described in Report 64, U.S. Agricultural Department, pp. 174 *et seq.*

The apparatus is made to revolve at a rate which causes all the sand and silt to precipitate; after which the liquid, with clay in suspension, is poured off and filtered. What remains, which is in a fairly consolidated state, is extracted by means of a strong jet of water, and the process is repeated, the apparatus revolving at a somewhat slower rate for the separation of each coarser grade; and so on, until a mixture is reached in which silt and sand precipitate rapidly without centrifugal motion. The precipitate is then dried, and treated by means of sieves. Towards the end of this paper I shall describe a method of treating the clay in open tubes, which is somewhat more expeditious, and seems to give results as satisfactory as those with test-tubes.

Besides the great gain, in time, by this process, there is the not inconsiderable advantage of a much smaller quantity of distilled water being necessary. The unlimited quantity used in ordinary washing, either by decantation or by elutriation, is a great disadvantage; and, without distilled water, perfect separation of clays from silts and sands is unattainable. With ordinary public supply-water, there is liable to be a degree of flocculation which involves silt particles in compound clay grains, which gives to these deceptive hydraulic values, and in consequence incorrect results. The centrifugal method is free from these objections.

The process is admirable for the separation of clay from silts, and the finer silts from the coarser; but as the test-tubes admit of dealing with such small quantities as ten grammes, a serious drawback is presented in dealing with earths presenting a great range of unevenly graded particles, such as commonly occur in our Irish Boulder-clay soils. By the time several grades of the finest particles are removed from the mixture, so little remains to be treated with the sieves, that correct returns can scarcely be reckoned upon in the remaining grades of material, up to two millimetres in diameter. To meet this drawback, I have devised a means of dealing with larger quantities—from twenty to thirty grammes of material. The means is a combination of Whitney's method with that of Bennigsen.

The apparatus used by Bennigsen[1] consists of a flask with a long graduated neck. The flask, when partially filled with the prepared mixture, is inverted and receives a pendulous motion. The coarser particles fall first to the bottom, followed by others according to their grades and hydraulic values; and the quantities are volumetrically measured by the divisions. This, of course, is but a very rough approximation to accuracy.

Adopting the idea of an inverted flask, I attach a tube firmly to it, so as to make this serve as a prolongation of the neck. Into the flask thus fitted, earth is introduced, and distilled water poured in, so as almost entirely to fill the neck with clear liquid. The tube is then corked (with indiarubber stopper), a sheath of tin is slipped down over the neck and secured by pliable copper wires to a leather base or cradle, which fits closely to the bottom of the bulb, and bears the extreme statical pressure resulting from the rotatory motion. The flasks are then fixed securely on the centrifugal table, in the manner to be described, with the bulbs inward and the tubes outward, the extremities being about fifteen inches from the axis of rotation. When the table is revolved for a short time, at 900 revolutions per minute, the coarser particles become precipitated, and so consolidated that, at the close of the operation, when the flask is removed from the table and held with the bulbs downward, the sand and coarse silt remain in the tube, and the clay and fine silt, forming the fluid mixture, are found in the flask (fig. 1, A and B, page 226).

The chief advantage of the apparatus is that the detachable tube admits of the easy removal of the sand and silt. The mixture might be graded volumetrically—if it be required, as is often the case, roughly to estimate the proportions of sand to the silt and clay. It is preferable to push the well-formed core out of the tube, and leave it to dry on a tray, when the sands and some silt will be found in favourable condition and sufficient quantity for grading by means of sieves.

The detailed procedure, as practised in the examination of soils and subsoils at the Geological Survey Office, is as follows:—In the case of fine homogeneous earths, a quantity of soil or subsoil, dried and averaged, is taken, and passed through a 2 mm. sieve; of this 20 grams if a sandy soil, 25 if a loam, and 30 if a clay, are taken for treatment. It is boiled with distilled water for some hours, to loosen the clay from the sands and silts. The mixture is

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[1] Described by Wiley, Principles and Practice of Agricultural Analysis, vol. i., p. 195.

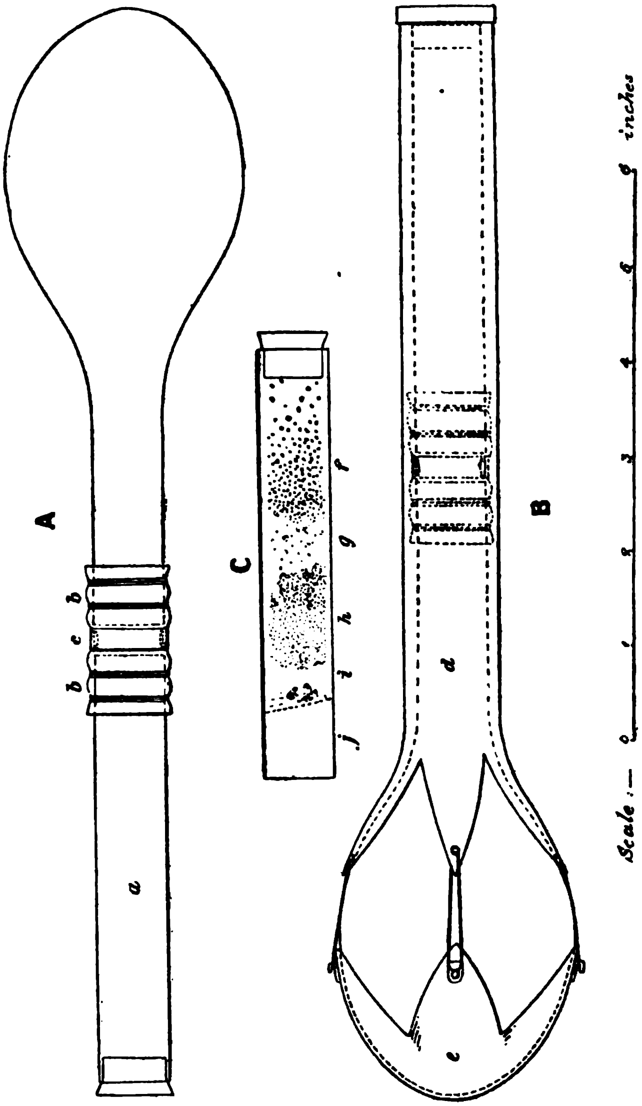

Fig. 1.

A. Flask and tube connected—*a*, tube; *b*, indiarubber tube connection tied with copper wire; *c*, leather collar to prevent bulging.

B. Sheathed tube—*d*, sheath (of tin) fastened to *e*, the leather base of flask.

C. Differentiation of grades (*f*, *g*, *h*, *i*) from a fluid mixture, by centrifugal action; *j*, space left free of liquid after inversion of tube and flask.

then thoroughly shaken to break up the compound particles and detach the clay from the sand particles. It is then transferred to the flask, and the latter nearly filled with distilled water to within an inch of the outer end of the connected tube. If this be carefully done, the neck is filled with clear water. The sheath is run down over the tube and neck of the flask, and fastened to the base of the flask. The *bulb* is then shaken to detach all particles from the bottom, and the whole inverted. The coarser sand and silt fall down through the clear liquid in the tube, and are thus free from clay particles.

The director of the Geological Survey has kindly given permission to show the apparatus, made according to my instructions, by Messrs. Booth, Bros. Its chief portion is the centrifugal table, consisting of two parts connected by means of a hinge, with two finger-screws, and carrying two wooden flask-rests, with leather sockets. The table is perforated with a slot-hole for the steel axis, admitting of the upper leaf of the table being raised ; and permitting of an additional axis with four projecting arms being affixed, when it is desired to carry out finer separations according to Whitney's method. The whole is actuated by a small lathe, and turned by hand (fig. 2, page 228).

Two flasks, prepared as above described, are now placed in leather sockets on the centrifugal table, which for the purpose is tilted up vertically on the hinge. If the flasks remained for any length of time on their sides, the suspended matter would precipitate on the tube and neck throughout their length, which would mar the process. When both flasks are set vertically in their sockets, they are revolved into position where they are retained by catches ; and the table is lowered into its horizontal position, and fastened by the finger-screws. The apparatus is then ready for rotation.

The rate of movement, which, with the radius already mentioned, throws down silts less than ·1 mm. in diameter, I find to be about 900 revolutions per minute when this rate is continued for about 1¼ minutes. At the end of this time, revolution is stopped, the flasks taken off, the sheaths removed, and, when the bulb is detached, holding it downward, the sand and silt core is found partially consolidated in the tube, while the clay, mingled with the finest silts, remains in suspension in the flask. Two separations—those of a soil and subsoil collected near Cork—have been made: cores placed on a drying-tray, and the separated fluid mixtures of silt and clay in flasks reserved for further treatment. I have examined the coarsest part of the silt remaining in the liquid, and find that, under the microscope, with a micrometer, it shows only a very rare particle, ·1 mm. longest diameter. The particles range from ·1 mm. downward.

When the cores are dried, they are graded by passing them through a series of four sieves, 1 mm., ·5 mm., ·25 mm., and ·1 mm.

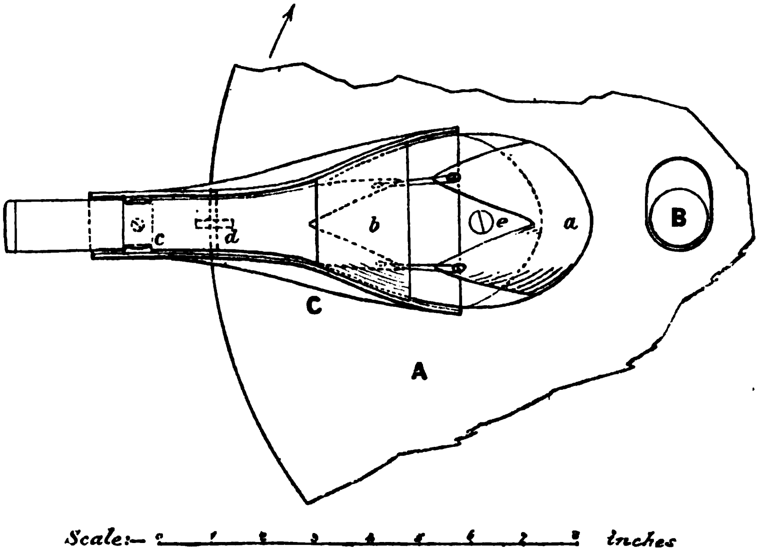

Fig. 2.

A. Centrifugal table. B. Rotation spindle. C. Flask-rest (of wood) shaped to flask, and fastened to table by means of screw-bolt (*e*); *a*, leather base of flask; *b*, leather socket holding flask, and securely fastened to rest; *c*, spring to retain sheath during rotation; *d*, notch in table to hold rest in position.

The silt, and any clay remaining in the core which passes through the ·1 mm. mesh, are added to the contents of the flask.

It would be attended with risk to attempt carrying out the process without a screen, which I have had made with sheet-zinc in the form of a short cylinder or drum. It is arranged to be lowered and raised at pleasure, and guards effectively against accident.[1] The driving wheel of my lathe can without difficulty be turned at sixty-eight revolutions per minute—a speed judged by means of a pendulum approximately 35 inches in length, in our latitude.

With the wheel revolving at this rate, the table rotates at the rates of 900, 1350, and 1800 revolutions per minute respectively. The cores shown are the result of 900 revolutions per minute for a minute and a half in each case.

To ascertain the degree of definition attainable on treating a mixture, I have taken as a basis of volumetric estimation the following variously coloured substances of the same specific gravity, and graded them, viz. :—

White limestone, ...	2-1 mm.; ·5-·25 mm.
Very dark-grey limestone, . .	1-·5 mm.; ·25-·1 mm.
Powdered chalk, ...	under ·05 mm.

Of these grades the following quantities were taken, and placed in each of two flasks :—

2-1 mm., ...	4 grammes.
1-·5 mm., ...	4 „
·5-·25 mm., ...	4 „
·25-·1 mm., ...	4 „
Less than ·05 mm., ...	8 „

A fluid mixture was made, the flasks filled with water, as described, and rotated. The two cores formed were shown, one in its tube, and the second on the drying-tray. The results are striking, but the separations are not sufficiently defined to admit of volumetric determination. The larger particles from 2 mm. to ·5 mm. are those which are most mixed; due, probably, to many of them being flat, and not capable of descending in the fluid as fast as smaller ones, which are roundish in shape. The line between the finest grades is most definite, owing probably to the hiatus between the grades in this case, those between ·1 and ·05 not being represented (see C, fig. 1).

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[1] Not having such an arrangement upon the spot, only the centrifugal table and its adjuncts, already described, could be shown to the meeting. Mr. Moss was good enough to supply an apparatus by means of which the rotatory movement could be illustrated.

The centrifugal force at the outer extremity of the tube is 802 feet per second, that is, twenty-five times greater than gravity; that at the inner end of the flask is 185 feet per second. These give a statical pressure of some 7 lb. per square inch. The pressure is carried back to the inner end of the flasks, when set on the table, by attaching the tin tube to the cradle enclosing the bulb, the egg-like shape of which resists the pressure. When relieved of this strain, the flasks sometimes crack, which has suggested to me the necessity of henceforth connecting the tin tubes to the wooden flask-rests, so that the latter may bear the pressure instead of the bulbs.

In dealing with the fluid mixture in the flasks, after the sands, &c., are separated from it, an aliquot part is taken and placed in a thick tube open at both ends, one of which is corked with an indiarubber stopper. It is then closed with another such stopper, allowed to rest until the liquid in the upper half is clear, and inverted, the end holding the deposit (*only*) shaken to and fro, to detach the deposit, and placed in the swing attached to one of the arms. A second tube, with a second mixture, is similarly prepared, and placed in the opposite swing; and the axis bearing the arms revolved at 900 turns per minute for one minute for the first of these finer separations. Silt will be found consolidated at the end of the tube; and, after pouring off the liquid, the deposit is withdrawn by removing the lower stopper, and placed on a filter-paper in a funnel. The adhering particles are washed on to the filtered paper, and it is dried and weighed.

This process is repeated with the liquids at the two higher velocities; and what remains in the liquids finally is clay only. The particular rates of rotatory motion, and lengths of time necessary for each process, I have yet to determine.

It can hardly be claimed for these processes that they give absolutely correct results; but they give a near approach to strict accuracy, and furnish rapid means of comparing large series of soils and sub-soils, which, except for purely academic work, where abundance of time is at command, is a desideratum.

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XI.

FORESTS, WILD AND CULTIVATED.[1]

By AUGUSTINE HENRY, M.A., F.L.S., L.R.C.P. (Ed.).

Plates IX.–XX.

I. Wild Forests.

Man, since he emerged from the purely hunting stage, has been at work destroying the natural forest. The primitive modes of this destruction may still be observed in countries like China, where in the south, for example, the Yaos, a semi-hunting tribe, who always live in isolated villages, on the margins of virgin forests in the high mountains, cut the trees around them, as out of the bamboos, which form the dense underwood, they manufacture paper, and in clearings they cultivate certain drug-plants and indigo. Other tribes indulge in what I term nomadic agriculture ; they burn down areas of the forest ; gather one or two crops of millet or upland rice from the rich forest soil ; and then pass on to another district, where they repeat the destruction. With people in a higher stage of civilization, forest clearings are effected more rapidly ; and all the good land, which was generally covered primitively with trees, becomes the seat of agriculture and pasture. In addition, there are vast demands made upon the forest for fuel ; and in most countries, primitive iron works have been, perhaps, the chief cause of the destruction of vast forest regions.

In our own country the destruction of the forests is well-nigh complete. Nearly every bog is the site of an ancient forest. It appears to be an almost constant rule that, once forests are cut down by man, it is with great difficulty they are naturally reproduced. In warmer countries, desert- or grass-land is now found where ancient forests stood ; and in the northern temperate zone, the invasion of heather and production of peat-mosses constantly occur where the climate is moist. The heather, a social plant, will not grow under the shade of trees; but when these are cut down, it invades the felled area, and it may be supposed to poison the soil, for only a few trees will grow on heaths, and scarcely any on bogs. At any rate, regeneration is always difficult in such situations, and is impossible where cattle have access. Little can be alleged against the utilization of good soils for farming or grazing; but in most parts of the world there are immense areas, once clad with trees, which are now covered by coarse grasses, or are semi-deserts, or heaths, or bogs ; and all such cases are economically disastrous. Waste lands, unsuitable for farm crops, or useless as pasture, are the results of man's ancient ruinous agency ; and on the Continent it is now accepted as an axiom that such areas should be, where possible, re-afforested.

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[1] Lecture given before the Royal Dublin Society, February 5, 1904.

Plate IX., fig. 1, represents a hill in central China, covered with coarse grass, useless as pasture, and impossible to cultivate. In such regions farming is carried on only in the rich land of the valleys. Plate IX., fig. 2, shows a Yao village in the Shan States, where the primitive people are making the first onslaught on the primeval forest. Plate X., fig. 1, depicts the remains of an ancient forest in Donegal, near Mount Errigal.

In Europe, primeval forest only remains in a few isolated districts. In Ireland, an oak forest, a mile square, in a virgin condition, exists still on the Clonbrock estate; and at Killarney there is the remarkable association of arbutus and oak, which constitutes a type of forest quite unique, as here the arbutus reaches the dimensions of a forest tree, and, mixed with the oak, keeps possession of a considerable area of rocky soil. In France and southern Europe generally, the arbutus is only a shrub. In our glens, here and there little bits of ancient forest remain; and Mr. Welch, of Belfast, informs me that in such woods peculiar land shells occur, which are never found where the soil has been disturbed by cultivation.

It is difficult, now-a-days, from the paucity of true virgin forests, to study the primitive condition of the earth's surface, upon which man has been such a disturbing agent. We know that a contest is continually going on between the wood-land

and the grass-land; and while generally the success of one or other depends upon climatic factors, yet I believe no adequate explanation has been given of the general phenomenon that, where forests are destroyed by man, grass-land takes the upper hand.

It is, however, possible to give a fairly adequate account of the garment of the earth in ancient times, before man had begun to exercise his disturbing influence. In that epoch the earth was covered either with large tracts of grass, or with wood-land, or—in regions subject to drought or extreme dry cold—it was desert. A desert is a territory where individual plants are separated by wide intervals of sand or rock. It is rare for a desert to be entirely devoid of plants, as even the Sahara has a flora. In the popular imagination deserts are only associated with hot regions; but two other types occur. There are the tundras, which occur in the northern partsof Russia, Siberia, and North America, where such plants as occur are isolated, stunted in form, and mostly of low organisation, as mosses and lichens; and the Alpine deserts which occur in the Himalayas between the grass-land and the snow-line.

In the regions free from desert, either grass-land or wood-land prevailed; and the occurrence of one or other depended entirely upon climate. A grass-land is covered with perennial grasses, growing in tufts and intermingled with many kinds of herbs. Grasses are shallow-rooting plants, and as such are dependent for their existence upon the continuous presence of moisture in the superficial layers of the soil during the vegetative season. The uppermost layer of the soil speedily dries up; and grass-land is only possible when there are frequent rains in spring and summer. Trees, unlike grasses, are deep-rooting plants. By their spreading network of roots they tap deep-lying sources of water. Trees will accordingly grow if the deeper parts of the subsoil contain water, and it does not practically matter, provided the annual rainfall is large, at what season the rain falls. Trees occur in regions like the shores of the Mediterranean, where there are long seasons of drought. The greater the amount of moisture in the subsoil, the taller will be the trees, and the more luxurious their growth. As trees transpire moisture in enormous quantity, calmness of the air helps their growth, as winds cause excess of transpiration; and in frosty weather, when water cannot be taken up from the soil by trees, dry winds will kill them. In extreme Arctic regions trees are not found, simply on account of the cold drying winds of the Arctic winter. It is not the low temperature in itself which stops tree-growth, for the coldest part of the earth's surface is in the Siberian forest district.

In mountains, to a considerable altitude, there is a heavier rainfall than in the adjoining plain, so that the subsoil is kept continuously wet. As a result, the slopes of mountains are commonly covered with forests. Higher still, on lofty mountains, the rainfall diminishes, and strong winds prevail; and, in consequence, we find above the timber-line the Alpine grass-land, which in Europe extends up to the snow-line.

A good wood-land climate consists, then, of the following elements:—A warm season of growth, a continuously wet subsoil (heavy rainfall), and calm, damp air, especially in winter. Climate is thus the important factor. Soil only exerts a modifying influence. Heaths cover large tracts in Europe; and they probably owe their existence to the poverty of the soil, which satisfies the wants of the common heather, but is inadequate to the requirements of trees, or is even poisonous to them. In Norfolk, the heaths, however, if enclosed against cattle, are rapidly repeopled by the common pine, provided the subsoil is porous sand containing water; and the conversion of heath-land into wood-land is easy in many districts with slight aid from man. Near bodies of water the subsoil remains moist to a considerable depth, and this is why the margins of rivers and lakes are covered with woods. These "fringing forests" are often of considerable importance, and may be as luxuriant as forests in the best forest climate. The swamp forests of Florida, and the mangrove forests which fringe the sea-coasts in the tropics, are peculiar communities, which are due to special soil-conditions. The occurrence of rocks will prevent the growth of either trees or grass; and on them we may find only plants occurring here and there at wide intervals. However, in moist climates, rocks are rapidly weathered, their decomposition being hastened by lowly vegetable organisms: algæ first appear, then mosses and higher plants; and in the end, what were once barren rocks become covered with forests of great luxuriance.

Many splendid forests, as will be alluded to below, occur in the mountains of France in such difficult positions. Plate X., fig. 2, is a picture of the Scalp in County Dublin; one side of the pass is covered by a fine plantation of pine, while the other side is a semi-desert, with scattered grass and whins occurring here and there amidst the rocks. On the precipice of the Scalp, next the pine plantation (see Plate XI., fig. 1), trees may be seen taking possession of a rocky and barren situation. The leaves blown over from the plantation have collected in crevices, and have formed, by their decay, pockets of humus in which seeds have fallen, which are growing up into trees. The Scalp illustrates very well one great advantage of tree-growth, *i.e.* that it actually creates soil, and always improves its fertility. The rocks, rent by the disintegrating action of the roots of the trees, are decomposed by the carbonic acid which is formed abundantly in the humus resulting from the decay of fallen leaves.

There are many types of wood-land on the earth's surface, and I may glance at some of these briefly. In the tropics, in regions where rain falls constantly, the so-called rain-forest prevails, in which the trees are all evergreen. Where wet and dry seasons alternate, there is the monsoon forest, in which many deciduous-leaved trees occur. In still drier regions are the tropical savannah-forests and thorn-forests. In the warmer part of the temperate zones, we have also a rain-forest of evergreen trees: broad-leaved trees in ordinary soil, and conifers where the soil is sandy or swampy. This forest occupies regions where there is an abundant rainfall. In parts where the rainfall is lessened, but where it is still considerable in summer, we have thorn-forests and savannah-forests, including peculiar formations like the eucalyptus and acacia forests of Australia, where the grass grows freely between the trees. In the districts of the warmer belt of the temperate zones, where the climate is characterized by rain in winter and prolonged drought in summer, we have an evergreen xerophilous forest, made up of trees with thick leathery leaves. In the more northerly belt of the north temperate zone, two types of forest occur—the summer forest, composed of deciduous-leaved trees, and the coniferous forest. All these different types are explicable by climate factors alone, slightly modified by conditions of soil.

It is impossible in the limits of a short paper to consider all these types, but one or two may be glanced at. In the tropical rain-forest we are struck by the abundance of epiphytes (plants which live upon trees, like so many orchids and ferns) and of climbers, which everywhere cover the trees. In a tropical forest there are four or five stages—the herbs on the ground; above these a tier of shrubs; and still higher, two or three tiers of trees attaining different heights. Tropical trees have often immense buttresses, which are plank-like out-growths from their base, and as a rule they are much less branched than the trees of our own region; indeed, in tree-ferns, palms, and cycads, branching as a rule does not occur at all; while in higher types it is only carried out to the third order. Another peculiarity of tropical trees and climbers is the frequent occurrence of the flowers on the branches below the leaves or on the stem itself, and not with the leaves on the current year's shoot, as is the case in all our trees.

Plate XI., fig. 2, is *Bombax malabaricum*, a deciduous-leaved tree of the monsoon tropical forest, the specimen photographed occurring in a low valley in the Shan States. It shows very well the characteristic branching of tropical trees, the flowers being borne on coarse branchlets. Such trees as the elm, with its fine ramification and delicate spray, do not occur in tropical forests.

In the northern cold temperate belt, two types of forest occur, the deciduous-leaved forest, and the coniferous forest. For normal tree-growth in this belt, a rainfall of at least 20 inches yearly is necessary. In Southern Russia, the steppe is an extremely rich soil, yet trees are entirely absent, owing to the rainfall being less than 20 inches, and to the prevalence of strong, dry easterly winds. In spring and summer there are frequent showers, and the climate is thus one favourable to grass-land, and we have in consequence the treeless, grassy steppe. Similarly in the United States, rainfall is abundant at all seasons of the year in the Atlantic district, and we have here a true forest climate. Before the advent of the European, the whole country between the Mississippi and the Atlantic was covered with trees. Between the Mississippi and the Rocky Mountains there is a dry winter, followed by a moist spring and early summer—conditions favourable to grass-land. Moreover, in this region, the north winds are persistent and dry, waging war against tree-growth: as a result, we have the grassy, treeless steppes known as the prairies. Proceeding further west, a desert climate prevails on the Rocky Mountain and Sierra Nevada plateau. The Pacific slope has an abundant rainfall, and a maritime climate; and in consequence the forests are magnificent.

The deciduous-leaved forest of colder temperate regions has at most three stages—the herbs on the ground, the shrubs, and one tier of trees, which reach a nearly uniform height. Creepers are few in species, and sparse in quantity (clematis, ivy, honeysuckle, hop). Epiphytes, at least of higher plants, are rare: indeed, only one occurs, the polypodium fern. The trees are bare, or their bark only bears lichens and algæ of no great size. This broad-leaved forest is generally mixed, when man's action does not intervene, and composed of many species, though certain ones predominate. Each species has different requirements as regards the fertility and humidity of the soil. Alders and willows flourish near water. The ash and sycamore demand a rich soil, and only occur in woods disseminated in little groups, or as isolated trees. In Europe, pure forests of deciduous broad-leaved trees are practically only formed by beech and oak. On poor soil, there may be communities of birch, which is a frugal tree, that will exist where other trees cannot find sufficient nutriment of mineral matter. The different requirements of trees have an important bearing in sylvicultural practice. There is, *e.g.*, the distinction between shade-bearers and light-demanding trees. The beech is a shade-bearer; it has a dense crown of foliage, and underneath its shade the young beech seedlings will grow, but not those of other trees. Trees like the beech will grow crowded together in dense masses. The oak is a light-demanding tree, with a much less dense crown of foliage, and its young seedlings will not grow under cover. Moreover, when the oak reaches a certain size, the trees will not bear close crowding together, and this peculiarity necessitates different treatment of an oak-wood from that of a beech-wood. The beech is of the greatest utility as a forest tree, as its dense foliage prevents evaporation of the water of the soil, and when it falls, enriches the ground with humus. Only social trees are cultivated in extensive forests, as it is impossible to keep up pure woods of sycamore or ash on the poor soils, which are the only ones left now for the cultivation of trees. The single leader of the ash and sycamore, however, enables their seedlings to pierce their way through brushwood, thorns, briars, etc.; and is a distinct peculiarity in their favour for certain situations.

In the deciduous broad-leaved northern forest, the rich and transient spring flora is very characteristic. The shrubs become greener earlier in spring than the trees that are above them; and the ground is decked with herbs like the anemone, which go through their leafing, flowering, and fruiting before the leaves appear on the trees. The only part of these herbs that remains alive in summer is their underground stems. Certain herbs, however, do occur in these forests, which last through the summer, as they can bear shade (wood-sorrel, ferns). Other plants, as winter-green, orchids, and the enchanter's night-shade, can live in the woods, because they derive their sustenance in part from the humus.

In winter, when cold, dry winds blow, and the ground may be frozen for long periods, these broad-leaved trees are protected against transpiration of water. Their leaves fall, and this of course diminishes enormously the transpiring surface. Their stems and branches are generally protected by a layer of cork, and their buds by scales, which are resinous, or gummy, or clothed with downy hairs. The leaves, which remain only on the tree in summer, are delicate in texture, are not protected against transpiration, and stand on the twigs, so as to receive as much light as possible. They differ remarkably from such trees as the eucalyptus of hot Australia, which bear their leaves sideways on the twigs. They are also very different from the hard, leathery leaves of the Mediterranean evergreen trees. Their leaves are also much smaller than those of tropical trees. In our forests, we have a few evergreen trees, as holly, box, and arbutus: these have thick and leathery leaves, which do not transpire freely.

The coniferous forest, which is so characteristic of the northern temperate belt, has leaves, which are amply protected against transpiration in winter. A pine transpires only a tenth of the water transpired by a beech. As a rule, coniferous forests occupy colder districts than do the broad-leaved trees in the north temperate belt; they thus spread to the north, and ascend higher in the mountains. This explanation is only a general one, as mixed forests of conifers and broad-leaved species occur naturally; questions come in of soil, *e.g.*, pine woods take possession of sandy soils and heaths in regions where on other soils broad-leaved trees predominate.

Before passing on to the second part of my subject, I may lay emphasis on the point, that so far as regards the general conditions which govern tree-growth, we have in Ireland an ideal forest climate. There is a heavy rainfall, a mild climate, and an absence of cold, drying winds in winter. The strong south-westerly gales render, it is true, by their mere mechanical action of uprooting, the life of isolated trees, or narrow belts of timber, precarious. There is, however, no difficulty in establishing protective belts, chosen from such species as bear readily salt spray and strong winds; and under the lee of such belts, the more valuable kinds of trees can be successfully planted.

II. CULTIVATED FORESTS.

In wild forests nature covers the ground with trees, which, however, do not satisfy man's requirements. There are many species occurring in the wild forest, which are practically weeds, being useless as timber; and the irregular growth of even the good species makes their timber less valuable. The art of forestry consists in maintaining the good species which live in a social state, and in eliminating the worthless kinds, and inferior and diseased individuals of even the good species. Trees are grown in dense masses, because thereby tall, straight stems are obtained, which constitute valuable timber; and, at the same time, the ground is kept covered by the dense shade of the foliage of the trees, and by the layer of their dead leaves on the soil, which enrich it with humus, improve its quality by chemical and other changes, and protect it against evaporation; so that the subsoil is kept continuously wet. To improve the condition of the soil is the *main* object of the forester, just as it is of the farmer; and as the forester is deprived, on account of the expense, of extraneous fertilizing agents, he is compelled all the more, if he is wise, to utilize the great fertilizing agent of nature—the litter of leaves. The ground must be kept covered, and protected from sun and wind.

Certain species of trees—those known as shade-bearers—will grow in dense masses until they attain maturity; and with these there is no difficulty in keeping the soil covered. Others—the light-demanding kinds (the oak and larch, for example)—will not bear crowding as they reach the end of their growth; they clear themselves (as is said), and will only grow with their crowns of foliage isolated; and, in consequence, the sun and wind begin to act upon the soil, which becomes hard and bare of leaves (blown away by the wind). The soil rapidly deteriorates, with bad results to the growth of the timber on it. To obviate this condition, such forests are either mixed with (from the beginning) or underplanted (afterwards) with shade-bearing species, the object of which is to protect the soil to the end of the growth of the dominant light-demanding species.

Two types of forest are cultivated—*high forest* and *coppice*. In coppice the trees grow from shoots which spring from the stumps of felled trees; whereas in high forest the young trees are seedlings. Pure coppice is cultivated mainly for firewood or for special products, as for oak-bark, hop-poles, vine-props, etc. In *coppice with standards*, shown in Plate XII., fig. 1, the advantages of both systems are sought after. The standards are isolated large trees, as oaks or beeches, mainly regenerated by seedlings, and cut down for timber at intervals of one hundred years or so. Between the standards grows the coppice of hornbeam, lime, etc., which is cut down every twenty or thirty years, and is utilized for firewood. Coppice, owing to the lessening value of firewood and bark, is becoming a non-paying crop; whereas high forest, owing to the diminishing supply of the timber of the world, is more and more desirable; in the creation and maintenance of high forest, we are restricted to the few species that will grow socially. There are among conifers, the larch, silver fir, spruce, and pine; while of deciduous-leaved trees, the oak and beech are the most important.

The moment a forest is felled over a large area, the expenses of replanting are considerable, as the sum, however small at first, mounts up with compound interest to an enormous figure by the time that the timber is mature. Moreover, on such areas the young plants are placed in a bad condition to withstand the growth of weeds, grasses, and worthless shrubs and trees, which speedily take possession of the ground. The French have generally adopted, instead of artificial planting, the system of natural regeneration; the forest is cut down by a series of fellings, spread over a term of years, and conducted so that by the time the final cutting is made, the naturally born seedlings will be in complete possession of the soil. In the *regular system* of regeneration fellings, the forest is divided into sections, in one of which a primary cutting is done each year, the whole course of fellings being so arranged as to give a steady annual income.

This system is well carried out in the magnificent oak forest of Bercé, in France. Plate XII., fig. 2, shows a portion of the forest, with the trees about 200 years old, and thus arrived at maturity. On this section a primary regeneration felling is made; about half the trees are cut out all over the section. Those which are left standing are the finest and largest seed-bearing trees (see Plate XIII., fig. 1). The acorns germinate readily in the soil laid bare by the partial removal of the trees, and the young seedlings grow vigorously. As a rule, no operation is required to prepare the ground for the seed, though in bad spots, where grass and herbs have grown up, the ground is opened up by a slight hoeing. The seedlings gradually take possession of the ground; and during the next fifteen or twenty years a series of secondary fellings are made, which are effected wherever the seedlings are numerous. By the end of twenty years the final felling is done, and the last of the trees removed, and the seedlings now form a thick and continuous bed over the forest floor. The result of the secondary fellings is shown in Plate XIII., fig. 2. Plate XIV., fig. 1, illustrates the curious way in which the final felling is done, as the crown of the tree is lopped off by a woodman, who climbs up, and the stem thus remaining is cut down at the base afterwards. In this picture the oak in its forest form is very well shown; a tall cylindrical stem, some eighty to ninety feet in length, without a branch; the total height of the tree with the crown being about 120 feet. The crown is astonishingly small; and the unbranched trunk, all sound, useful timber, is remarkable.

Plate XIV., fig. 2, represents the young forest, after the final felling of the trees of the old forest, when the oak seedlings are in the *thicket* stage. Plate XV., fig. 1, shows the *young pole* stage, when the stems, somewhat older, have lost their lower branches, and are cleaning themselves. The trees eventually reach the stage in which they grow no more in height, but only in diameter.

When the seedlings are in a young state, *cleaning* operations are done by the woodman, who roams about the forest with a bill-hook, lopping off, wherever he finds occasion, the tops of such shrubs, or of such saplings of undesirable trees as stand above any of the young oaks, and are interfering with their growth.

Thinnings are the next operations. In France the object of thinning is never for immediate profit by the sale of the stuff cut down. Thinning is done solely with the object of favouring the best trees of the best species; all deformed, diseased, branched, unhealthy, or inferior trees of the species cultivated are removed gradually, and, at the same time, trees of undesirable species. Thinnings are directed solely against the stage in which the high trees occur; the shrubs and smaller trees which do not form part of the upper stage of the forest are never touched, as they help to cover the soil; and the preservation of the soil-cover, as explained before, is the main object of sylviculture. Thinning done severely results in the ruin of the soil, and deterioration in growth of the trees left standing, which become branched, and relatively low in stature, and so are lessened in timber value.

The value of the forest of Bercé is marvellous. The trees as they stood on one section were worth £1,000 an acre; and the value of the products of the whole forest, resultant from thinnings and fellings, averages £6 an acre.

In the *selection* system the forest is cut over extensive tracts every year, and the trees are felled either singly or in small groups of three or four, here and there, according as they become mature timber, or must be removed on account of decay or disease. In the regular system, just described, the felling is over a definite section of a certain area. However, in a well-treated selection-forest the same cultural attention, cleaning and thinning operations, are applied in the same way as in the other system, only over greater areas less intensively. The selection system is in vogue in mountainous districts, where natural regeneration on account of climate or soil is difficult, and where hurricanes are frequent, and it is not advisable to make any great openings in the forest mass by fellings.

The Vosges is a mountainous tract of France, where the soil is almost barren, consisting of 95 per cent. of pure silica with no lime, and the merest trace of phosphates. With such a soil, agriculture and pasture are impossible in the Vosges, except in the valleys; and yet, over eighty-five per cent. of the whole district, the mountains are covered by dense forests, composed of silver fir, pure, or mixed with beech or spruce. To give one example of the value of these forests, the 2,400 acres belonging to the hospitals of Nancy, situated at an average height of 3,000 feet, yield an annual income by the sale of timber of £4,000 net.

The silver fir is a pronounced shade-bearer, and its young seedlings spring up under the cover of the parent trees, and retain their vitality for a long time, although, of course, they will not grow vigorously until they are uncovered, and exposed to the light. The silver fir only succeeds in a climate which is very humid, and not too cold; and in nature it occurs as a tree of the lower parts of the mountains of central Europe. Both the selection and regular systems are in vogue with silver-fir forests. Plate XV., fig. 2, is a general view of a silver-fir forest in the Vosges.

At a considerable altitude the silver fir is difficult to cultivate pure, on account of the uncertainty of natural regeneration; and in such cases spruce is mixed with it. Young seedlings may also be introduced artificially from the lower levels.

In the Jura, which is of limestone formation, equally remarkable results are obtained. To quote one example: on the small chain of Risoux, there is a forest of spruce, belonging to several neighbouring communes, which is 6,500 acres in area, at 4,000 feet elevation; and it yields a net yearly income of ten shillings an acre. Here the conditions of soil and climate are so difficult—as the ground is almost pure rock, and cold, drying winds prevail in winter—that in most parts of this forest the young seedling spruces find no place to take root but on the decaying stumps of the felled trees, and in the crevices of the rocks, where falling leaves have decayed, and made pockets of humus. Here, of course, the selection system is adopted; no extensive fellings are ever made, where the hurricanes might enter and cause widespread devastation. Where young seedlings are found, a few trees over them are cut down to give them light, and the chance to grow up into big trees; and in this way the older trees are taken out as it were one by one, being replaced by the natural seedlings. The timber of the spruce of these high altitudes is extremely valuable, as the trees grow slowly; for the rule with conifers is that the slower the growth the better the wood produced. Hence follow the possibility and desirability of cultivating conifers in mountainous districts, as the slowness in growth is made up for by the improvement in the quality of the timber.

Plate XVI., fig. 1, represents a mixed forest of spruce and silver fir. Plate XVI., fig. 2, is interesting, as illustrating the importance of humidity of the subsoil. It is a spruce forest in the mountains, through which a road passes horizontally (from front to back in the picture). The road acts as a drain; as a result, the lower part of the wood (on the left of the picture) shows the trees growing densely and luxuriantly. The part of the forest immediately above the road (and drained by it) has the trees growing much less crowded, and they are not flourishing.

In the mountains of Central Europe, the natural succession of conifers is—the silver fir at low altitudes; the spruce higher up; the larch highest of all, and forming the timber line in many localities.

Plate XVII., fig. 1, shows the spruce in the Jura at 5,000 feet, where the Alpine grass-land begins. We see that the trees are isolated, the scene becoming park-like in character; and with the grass are associated plants like the white hellebore and the yellow gentian.

The larch, though extensively cultivated in this country, is an exotic, and is far removed from its natural conditions of growth. Its wonderful success, now rendered less certain by the disastrous disease which afflicts it, is an encouragement to seek in some other exotic conifer a tree that will replace it. The larch is an Alpine tree in central Europe, only descending to the plain in the cold and dry climate of Northern Russia. Plate XVII., fig. 2, shows a regular forest of larch at a high elevation, and exhibits very well how the tree—a light-demanding species—grows in its natural situation isolatedly, when it has attained a certain size. Such a forest presents a marked contrast to the dense mass of a forest of a typical shade-bearing tree like the silver fir.

The mountain pine, a very distinct species, not to be confused with the common pine or Scotch fir, occurs naturally in two kinds of situation in the mountains of central Europe, either in bogs or on rocky places, ascending, in the latter case, even higher than the larch. Plate XVIII., fig. 1, represents the species growing on a bog in the Jura, near Pontarlier, at 4,000 feet elevation. It is evidently a tree of some value for high mountain bogs; but at lower altitudes, the common pine is more suitable for mountain bogs, and does very well at Longemer, in the Vosges, in a bog, to which some manure and the ashes obtained by burning the heather and other shrubs have been added. Plate XVIII., fig. 2, shows the mountain pine, at 4,800 to 6,000 feet on the southern slopes of Mount Ventoux. It is the only tree which will cover the soil at such elevations. Plate XIX., fig. 1, represents the continuation of the same forest, higher up towards the timber line; and the trees, as they ascend, become smaller and smaller; finally, they are quite stunted and markedly isolated. On these high mountains, for protection against land-slips, &c., the French make artificial plantations of this species, which succeed on the most difficult and rocky slopes. Such plantations are part of the general works carried on by the French foresters on the high mountains, which are being gradually afforested to prevent land-slips, disastrous floods, and other calamities, which are the concomitants of bare Alpine mountains. The improvement on the mountain pastures is another work which is carried out by the foresters; drainage, irrigation, and periods of closure to cattle, are the chief means adopted for this end.

The protection of the land against the encroachment of the sea-sands, on certain parts of the coast, is another section of the forester's work; and in the Landes, the fixing of the dunes has gone on in conjunction with the afforestation of tracts that were formerly deserts. Years ago the Landes was a territory almost quite barren, inhabited by only a few shepherds on stilts, who herded scanty flocks of sheep, there being no towns, or villages, or cultivation. This vast territory was a series of sand-hills, built up by sand blowing in from the sea in the course of ages; and between the chains of sand-hills were marshes and lagoons. The entire country was unhealthy, malarious, poor, and miserable. The afforestation begun eighty years ago has resulted in the creation of the great forest of maritime pine, covering 1,500,000 acres (the greatest forest in Western Europe); and the whole territory is now healthy, full of villages and industries, and inhabited by a comfortable population.

From Bordeaux to Bayonne, by the beginning of the nineteenth century the sea-sand drifting in had covered the country with a series of dunes, rising to 250 feet high. The first remedial step was to erect along the coast a protecting wall; this great wall has been built by the foresters, not by any feat of engineering force (costly, laborious, withal inefficient), but by enlisting the ordinary forces of nature, the wind and plant-growth. To create this wall (and the work has often to be renewed), about one hundred yards from the sea, a continuous line of paling is put down, consisting of stout planks, standing about a yard above the ground, with short intervals between them, through which the sand drifts and serves as a backing. As the sand-bank rises around the paling, the planks are lifted up a few feet at a time; and a rough wattled fence is also run behind the paling, which is renewed as it becomes covered. Gradually the sand-hill is thus raised, till it is about 60 feet high; and it is then fixed by plantation of marrem grass (*Psamma arenaria*). It constitutes the littoral dune, and is a great bank of sand, the wall that protects the coast. By judicious planting, and transplanting, and thinning of the grass, the dune is made to assume a definite slope, that of maximum stability. Behind the littoral dune the land is planted with a mixture of seed of maritime pine, furze, and broom; and in this way the forest of maritime pine has been created. The trees are tapped for resin, which is refined into rosin and turpentine; and the wood of mature trees is used for pit props, railway sleepers, etc.

Plate XIX., fig. 2, shows women planting marrem grass on the dune. Plate XX., fig. 1, represents the tapping of the resin.

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Further south, near Bayonne, the maritime pine is accompanied by the cork oak, which is here at its northern limit. The naturally grown cork is of no value except for the rudest purposes. When the trees attain a certain age, this naturally grown cork is removed down to the cork-forming layer, which is at some distance in the interior. This genetic layer forms new bark, which grows in regular uniform layers, and constitutes the ordinary cork of commerce. A tree of 8 inches diameter in the forest near Bayonne will yield cork to the value of about six shillings; and there may be forty trees to the acre. Besides the cork trees, there are the accompanying maritime pines, with their product of timber and resin. Plate XIX., fig. 2, represents an oak from which the virgin cork has been stripped.

In the preceding I have drawn all my illustrations of cultivated forests from France, where there is an astonishing variety, dependent upon the varied nature of the soil, altitude, and climate of that country. The French are adepts at the economical use of the forces of nature; and their modern forestry appears to me to be due in large measure to the necessity under which the French have laboured, of carrying on their forests at a minimum of expense. Forestry to succeed in Ireland must depend upon a similar patient observation of nature, and careful utilization of the forces which she puts at our disposal.

[NOTE.

[NOTE.—For permission to reproduce figs. 8, 9, 10, 12, and 13, I am indebted to Professor Fron, of the Forest School at Les Barres.]

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PLATE XVI.

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XII.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1903. BY GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Consulting Entomologist to the Royal Dublin Society.

(PLATES XXI., XXII.)

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CORN AND GRASS INSECTS.

Crane-flies.

Tipula oleracea, Linn.

As mentioned in my last year's paper on Injurious Insects (4), the grubs of these flies must be regarded as among the most serious of the Irish farmer's commoner insect-enemies. Examples were received from a Wheat-field near Waterford in February; from a field of lea-Oats near Roundwood, County Wicklow, in May; from an Oat-crop near Culdaff, County Donegal, and from the "putting-greens" of the County Down Golf Club, also in May. Considerable space has been devoted to these insects by Theobald (16) in the first of a series of reports on Economic Zoology issued from the British Museum. He lays stress on the importance of destroying as many flies as possible in late summer and autumn, and suggests that the heavy rolling or brush-harrowing of pastures, when the flies are noticed to be swarming in the fields, would prove effectual for this purpose. But the most practicable means for preventing the ravages of the grubs is to make pastures as bare as possible, before breaking-up, by rough-mowing or grazing, and to put in a root-crop before a corn-crop is grown on old grass-land.

BEAN AND PEA INSECTS.

Spotted Crane-fly.

Pachyrrhina histrio (Fab.).

Crane-fly grubs of smaller size than those of *Tipula oleracea* were sent in May from New Ross, County Wexford, where they were said to be present in large numbers, causing much injury to the roots of Peas. These grubs are characterised by four very prominent conical processes at the hinder end (fig. 1, B); they evidently belong to a species of Pachyrrhina—a genus of Crane-flies closely allied to Tipula, but distinguished from the latter by their clear, yellow, black-spotted bodies, their thicker and shorter basal antennal segments, and by detailed differences in the wing-nervures. Theobald (16) has figured the grubs of *Pachyrrhina maculosa*, Meigen, and of *P. quadrifaria*, Meigen; our species differs from both, and I believe that it is referable to *P. histrio* (Fab.) (fig. 1, A), which, in the adult state, seems the commonest member of the genus in Ireland.

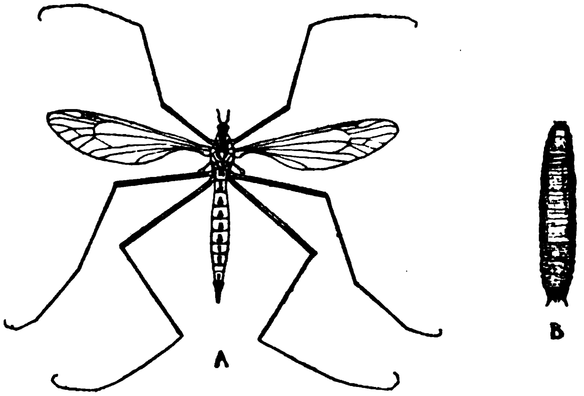

Fig 1.—Spotted Crane-fly [*Pachyrrhina histrio* (Fab.)].
A.—Female : × 1½.
B.—Grub : × 1½.

For destroying these grubs in garden-beds, Theobald suggests the use of traps, consisting of heaps of turf, partly buried in the soil, to which the grubs are readily attracted; also the injection into the soil of carbon bisulphide to the amount of half an ounce to the square yard.

Springtails.

Achorutes armatus (Nicolet), and *Lipura ambulans* (Linn.).

Through the Editor of the *Farmers' Gazette*, specimens of Beans were sent in June. The seeds had been eaten from the outside; and on them, as well as in the surrounding earth, were numerous examples of the two above-named species of the small wingless insects known as Springtails (Collembola). No doubt could be entertained that serious injury to the seeds was being done by these frail insects. They are frequently found in decaying vegetable substances; but they have been at times recorded as injurious to healthy plant-tissues, and it was of special interest to find a clear case of damage due to them. In September, 1902, I received the same two species from County Longford, with the statement that they swarmed over and partly devoured fruit left lying on the ground. We may, with confidence, therefore, add them to the list of injurious Irish insects.

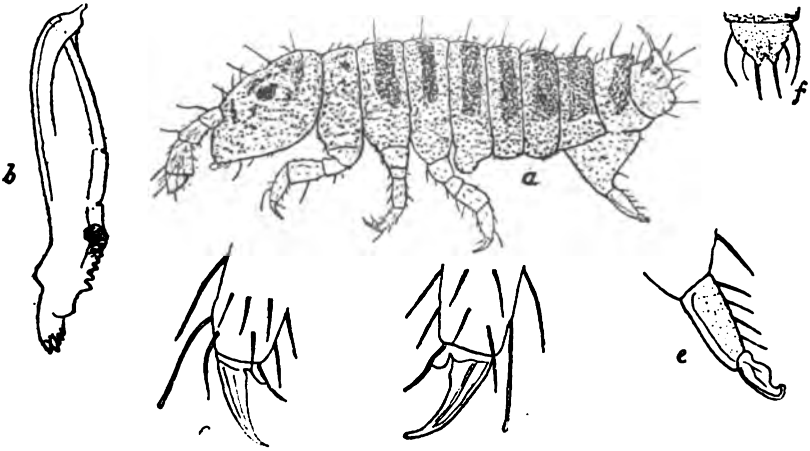

Fig. 2.—*Achorutes armatus* (Nic.). (*a*) Side view: × 40. (*b*) Mandible: × 250 (*c*) Fore-foot: × 250. (*d*) Hind-foot: × 250. (*e*) Tip of spring: × 250. (*f*) Tail-spines from above: × 40.

Springtails are wingless throughout their lives, and this condition is believed to be primitive. They are distinguished from the Bristletails (Thysanura), the other group of primitively wingless insects, by the reduction of the segments of the abdomen to six only; and the presence on the fourth abdominal segment of the characteristic "spring" which, formed by the fusion of a pair of appendages, enables the insects to leap. Further, the tracheal (air-tube) system is usually absent among the Collembola, which breathe over the general surface of the skin. In some genera the spring is vestigial or wanting. This is the case in Lipura (fig. 3), but in Achorutes (fig. 2, *a*, *e*) it is well developed.

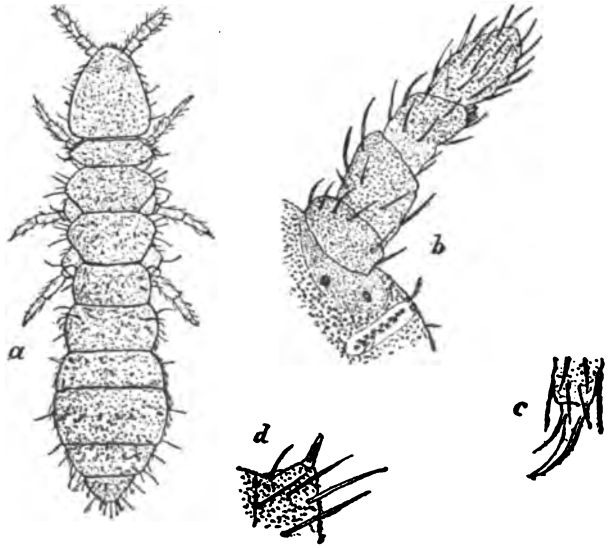

Fig. 3.—*Lipura ambulans* (Linn.) (*a*) Dorsal view : × 30. (*b*) Right feeler, with pseudocelli and post-antennal organ : × 150. (*c*) Foot : × 150. (*d*) Tail-spine, side view : × 150.

Achorutes armatus is distinguished by its long, slightly-curved tail-spines (fig. 2, *a*, *f*), the form of the terminal segment (mucro) of the spring (fig. 2, *e*) ; the presence of a single clubbed (tenent) hair on each foot (fig. 2, *c*, *d*), and the scattered transverse arrangement of the purple pigment over the pale yellow of the back (fig. 2, *a*). *Lipura ambulans* (fig. 3) is, like all the genus, white in colour, and without eyes. There are two short spines at the tail end (fig. 3, *d*), and the curious transverse "post-antennal" sense-organ (fig. 3, *b*) behind each feeler has fourteen prominences.

The jaws of Springtails are largely withdrawn into the head-capsule. The breaking-up of the substances whereon these insects feed is done for the most part by the mandibles (fig. 2, *b*), which can be protruded or retracted, brought into contact or separated, so that the teeth at the tip, and the grinding surfaces behind, can be brought into play. Thus, seeds and fruits are torn up and devoured by the action of multitudes of these tiny insects. Associated with the Springtails were a number of gamasid mites, which were doubtless preying on them.

Experiments are needed as to the best means for destroying the Springtails. In the present case, I suggested that seeds planted in suspected ground might be soaked in a half per cent. solution of formalin, and that, on account of the skin-breathing habits of these insects, and their consequent partiality for damp localities, lime should prove specially effectual as a dressing for the soil. Theobald (17) records that a dressing of soot and lime was effectual in killing Springtails that were injuring roots of cauliflowers and celery in South Wales.

POTATO INSECTS.

The Frosted Orange Moth.

Gortyna ochracea, Hübner.

Potato plants, with caterpillars of this moth feeding within the stem, were sent in June from County Kerry. The moth is rather uncommon in Ireland. The caterpillar feeds on various wild plants —Burdock, Thistle, Foxglove, &c.—in addition to the Potato—always burrowing in the stem, and eating away the soft, central tissue. The stem, much of its substance being thus destroyed, becomes unable to support the plant, which, after a time, falls over and ultimately dies. Injuries to Potato crops by this caterpillar have been reported by Ormerod (11).

The moth is a fair-sized "Owl Moth" (Noctuid), measuring about 1¼ inches across the outstretched wings, which are adorned with a handsome and characteristic pattern in purple and yellow (Plate XXI., fig. 1). It is found on the wing in September and

October, and the female lays her eggs, which remain unhatched through the winter, on the food-plant. In April the young caterpillars appear, and bore their way into the stalks, where they live until July or August, wandering up and down, devouring the pith as they go, and moving when necessary to another stalk. When fully-grown, the caterpillar (Plate XXI., fig. 2) is of a pale yellow colour, with yellowish-brown head, dark brown prothoracic and anal plates, and prominent, raised, black dots arranged regularly across the segments. The pupal stage is passed within the stem, a somewhat enlarged space being made before pupation by the caterpillar, and a hole eaten in preparation for the emergence of the moth (Barrett (1)).

On account of the internal feeding habits of these caterpillars, no insecticides can be brought to bear on them, and nothing but the obvious measure of destroying the injured stems, with their contained caterpillars, can be suggested.

Flea-Beetle.

Psylliodes affinis (Paykull).

Potato plants, with the leaves largely devoured by these small jumping beetles, were received in May from Kilrush, County Clare, and from Dundrum, County Dublin. Curtis (6) describes and figures this species under the name of *Macrocnema exoleta*, mentioning that in the year 1846 it occurred in multitudes on Bitter-sweet as well as on Potato crops. Theobald (15) also mentions and figures the insect. It belongs to the family of Leaf-beetles (Chrysomelidæ) and to the same section as those crucifer-feeding beetles which are commonly known as "Turnip-fly," having, like them, stout and strong hind thighs, which enable the beetle to leap into the air. The species of Psylliodes, to which the present insect belongs, may be readily distinguished from Phyllotreta (which includes the "Turnip-flies") and the majority of the jumping leaf-beetles, by having only ten segments in the feeler instead of eleven, and by the insertion of the basal segment of the hind-foot some distance before the tip of the shin (fig. 4). *P. affinis* measures about 2·5 mm. (= $\frac{1}{10}$ inch) in length. It is of a dusky yellow colour, but the head and hind-thighs are black, and there is a dark line along the suture of the wing-cases (elytra).

The habit of these flea-beetles is to winter in the adult state, and to lay their eggs on the young leaves in early spring. The larvæ are usually miners in the leaf-tissue, and there are successive generations through the spring and summer months. The oval eggs of the present species—about ·5 mm. ($\frac{1}{50}$ inch) long, with very finely-punctured surface (fig. 4, *a*)—were found beneath the leaves of the potato. Unfortunately, I had no opportunity of observing the larva, which seems never to have been described.

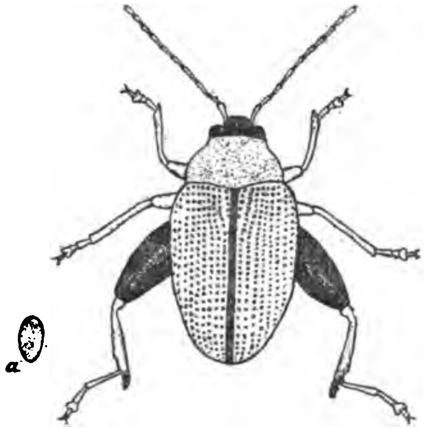

Fig. 4.—Potato Flea-Beetle (*Psylliodes affinis*, Payk.): × 12. (*a*) Egg.

It is likely that spraying with Bordeaux mixture, in many cases an efficient remedy for Turnip-fly, would destroy these beetles, or keep them from attacking the crop. Thus there is a double utility in such spraying, as a preventive both against fungal disease and insect pests.

CARROT, CELERY, AND ONION INSECTS, &c.

The Carrot-Fly.

Psila rosæ (Fab.).

The well-known maggots of this fly—the cause of "rust" in Carrots—were received during August from several County Dublin gardens, where they had injured the roots of Celery and Parsley.

Every season it doubtless does more or less damage to Carrots throughout the country.

The fly is a small insect about 4 mm. ($\frac{1}{6}$ inch) long, and 8mm. ($\frac{1}{3}$ inch) across the outspread wings. The body is blackish-green, the head and legs pale yellow, the eyes black, the wings iridescent, with yellow nervures. It belongs to the large group of flies allied to the Cabbage-fly family (Anthomyidæ), but with the scales at the fore-wing bases wanting, so that the reduced hind-wings (halteres) are readily visible. The female (fig. 5, ♀) has the hind-body pointed at the tip, while the corresponding region in the male (fig. 5, ♂) is blunt and rounded. The bristle of the feeler (fig. 5, *a*) is feebly feathered.

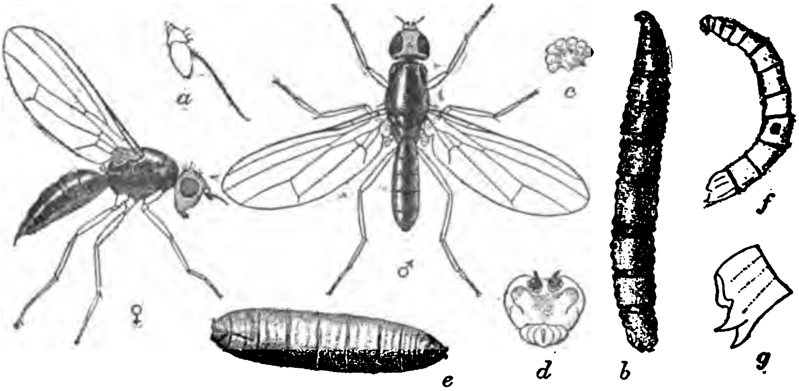

Fig. 5.—Carrot-fly (*Psila rosæ*). ♂ Male : × 8 ; ♀ Female : × 8. (*a*) Feeler of male : × 30. (*b*) Full-grown maggot : × 8. (*c*) Anterior spiracle of maggot : × 50. (*d*) Tail-end of maggot, showing spiracles and anus : × 20. (*e*) Puparium : × 8. (*f*) Young maggot : × 8. (*g*) Its hinder-end : × 25. From Chittenden, Bull. 33, U.S. Dept. Agric. (Div. Ent.).

The female fly makes her way through cracks in the earth to the surface of the carrots, and lays her eggs there. From these are hatched slender, white, fleshy maggots, with prominent conical processes at the hinder end (fig. 5, *f*, *g*). When fully grown, the maggot (fig. 5, *b*) is somewhat stouter, about 6 mm. ($\frac{1}{4}$ inch) long, and of a brown colour. Like most other two-winged-fly maggots, it is legless, and has no head-capsule, but tears up its food by means of protrusible mouth-hooks. The functionless, fan-like spiracle on the foremost trunk-segment (fig. 5, *c*) has seven lobes, while the functional spiracles at the tail-end are very prominent, black in colour, and upturned in a hook-like manner (fig. 5, *d*). The maggots feed in burrows and galleries which they gnaw in the substance of the root, mostly near the surface. In carrots the affected parts turn a peculiar red colour, whence the name "rust" applied to this attack. The roots sicken, and the leaves turn yellow and droop. When fully fed, the maggot leaves the roots and burrows into the earth, and its skin hardens and darkens to form the brown barrel-shaped puparium (fig. 5, *e*) within which the pupa is formed. After three or four weeks the fly is developed and emerges. There appear to be several successive broods through the warmer parts of the year. The winter is usually passed in the pupal stage, but in mild seasons flies may emerge, and maggots feed throughout the year (Curtis (6); Ormerod (12); Chittenden (5)).

Much may be done to prevent the ravages of this insect by clean and careful cultivation. In gardens it is possible by replacing thick heavy clay soils with a light mixture of peat or leaf-mould, loam, ashes, and sand, to prevent the occurrence of cracks through which the flies can creep down to lay their eggs on the roots. It is often found that the attack begins after thinning, the ground being then more or less broken up, and the smell of the fragments left lying about attracting the fly. The advice of practical men is to thin early, clear away fragments, and water freely afterwards. As the fly attacks Carrot, Celery, and Parsley, these crops should not follow each other in rotation. Paraffin and carbolic acid have been found the best insecticides for destroying maggots. Paraffin may be mixed with sand in the proportion of a quart to a bushel, strewed along the rows and watered in, or crude carbolic acid may be mixed with sand in the proportion of a quart to two bushels, and used in the same way. Watering with paraffin emulsion[1] is often useful, and was found most beneficial when applied to the Celery and Parsley crops attacked last year. If used after sowings, after germination, and after thinning, it acts both as a preventive and an insecticide.

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[1] See page 262.

Root-Mites.

Rhizoglyphus echinopus (Furnouze and Robin).

Specimens of Garlic, with the bulb and the bases of the leaves in an advanced state of decay, were received in August from Castleblayney, County Monaghan. Examination showed that the damage was due to the presence of swarms of small mites, which were to be seen crawling along beneath the scale-leaves, and among the ordinary leaves. Their progress could be traced by the extent of the injured surface of the leaves from the action of their jaws (Plate XXII., 1).

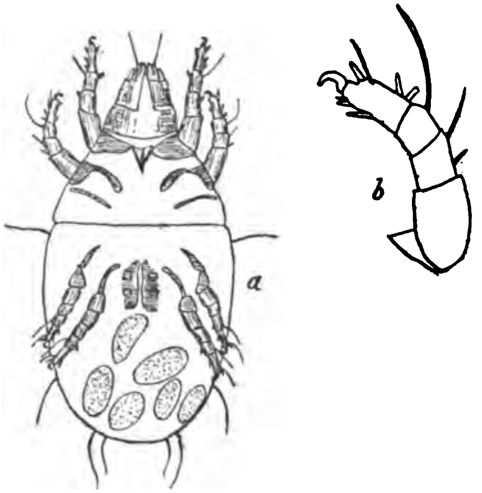

Fig. 6.—Root-Mite (*Rhizoglyphus echinopus*). (*a*) Female: × 70. (*b*) Second leg: × 150.

Mites form an order (Acarinida) of the class Arachnida, whose members (Scorpions, Spiders, &c.) can be distinguished from Insects by the fusion of the head with the fore-trunk, the absence of feelers, and the modification of the foremost limbs as seizing or piercing jaws. Four pairs of legs are usually present. Mites are distinguished from other Arachnids by the fusion of the hind-body with the cephalothorax, so that the primitive segmentation of the body is almost completely masked. The family Tyroglyphidæ, which includes the present species, together with the familiar Cheese-mites and Hay-mites, may be distinguished by the absence of a tracheal (air-tube) system, the function of breathing being performed over the general surface of the skin, by the usually soft-skinned body; the five-segmented legs terminating in a single claw; and the non-parasitic habit—the last character differentiating the family from the nearly allied Scab- and Itch-mites (Sarcoptidæ).

The genus Rhizoglyphus, to which the present species belongs, is nearly allied to Tyroglyphus (which includes the cheese- and hay-mites), but may be distinguished by its shorter and stouter legs, which are armed with strong spines, specially numerous and formidable in *R. echinopus* (fig. 6). The species has been most admirably described and figured in Michael's (7) recent "Monograph of the British Tyroglyphidæ." Among the interesting features of this species is the existence of some males with the legs of the third pair abnormally thickened. Like other Tyroglyphids, the first-hatched larva has only three pairs of legs, and several eight-legged nymphal forms are passed through before the adult stage is reached. *R. echinopus* is one of the species in which the special "hypopus" form of nymph is known to occur at times between two ordinary nymph-stages of the life-history. This hypopus is shown by Michael to be a firm-skinned nymph-form, specially adapted for ensuring the spread of the species by clinging to insects.

Abundant evidence is given by Michael of the injury frequently done by these mites in gardens, especially to the bulbs of hyacinths, tulips, and similar plants. He denies that these Rhizoglyphi habitually attack diseased bulbs, and states they "prefer sound bulbs, and will leave decayed ones and establish themselves in the fresh ones if they be placed close." In the present case, the damage to the plants could be most plainly traced to the activity of the mites which were making their way upwards from the bulbs and ravaging the leaves as they went. The scissor-like jaw (chelicera) of Rhizoglyphus is provided on either limb with three teeth. Thus the plant-tissue is cut up and liquid food sucked in by the mite.

On account of the concealed habits of these little creatures, no remedy against them can be recommended except the removal and destruction by burning of the injured plants. Michael suggests that "if the bulbs be very valuable, they may be had up, dried, carefully examined, and then treated with paraffin or creosote as strong as they will bear it, and the application should be repeated once or twice at intervals of a fortnight."

FRUIT-TREE PESTS.

The Black-currant Mite.

Eriophyes ribis (Westwood).

This destructive mite has been noticed during the year both in Ulster and in the neighbourhood of Dublin. As its prevalence threatens destruction to a valuable fruit-crop, a knowledge of its form, habits, and life-history is of much importance to gardeners and nurserymen.

Most mites, like Arachnids generally, have four pairs of limbs developed as legs for walking, but in all members of the family Eriophyidæ or Gall-mites, there are only two pairs of short five-segmented, forwardly-directed legs, each bearing at the tip a feathered bristle, and a very slender claw. The absence of the two hinder pairs of legs, together with the elongate, worm-like ringed body, furnished at the tail-end with a muscular disc and a pair of elongate bristles, serves to distinguish these Gall-mites at a glance. They are all of very small size (Nalepa (8)).

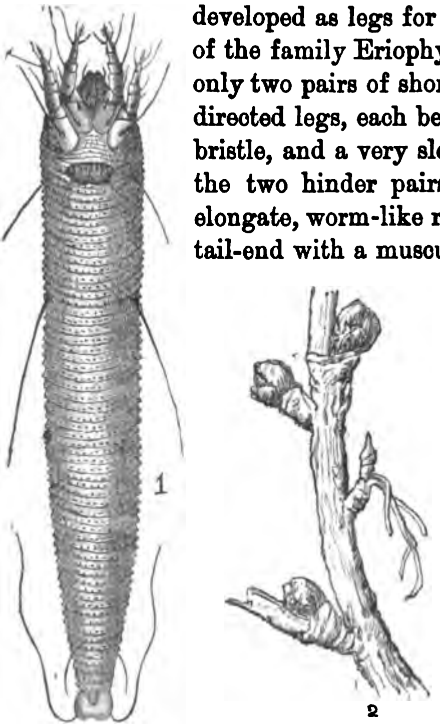

Fig. 7.—(1) Currant Gall-Mite (*Eriophyes ribis*): × 300, after Nalepa. (2) Galled buds. Natural size. From Ormerod.

The present species (fig. 7, 1) attacks both the Black and Red Currant, but causes serious damage only to the former. The presence of the mites is known by the enlarged and distorted appearance of the buds (fig. 7, 2) among whose rudimentary leaves they find shelter and food. Buds badly attacked by the mites remain swollen, green, and succulent for a long time, but rarely develop into shoots, and finally become hard and brown. If the number of mites in a bud be comparatively small, it may develop into a feeble and sickly shoot.

Our knowledge of the life-history and habits of these mites has recently been increased by the important researches of Warburton and Embleton (18), who find, in accordance with the observations of Newstead (9), that during May and June the mites—having spent the winter sheltered in the swollen, "galled" buds, which in early summer become dry and dead—crawl out of these old buds, now unable to afford them any more nutriment, and make their way to the new, young buds. The principal fact shown by Warburton and Embleton is that this migration from the old to the new buds is largely brought about by the agency of insects. The mites were observed to crawl out of the old, dry buds, and then to raise themselves upright on their tail-ends, supporting themselves by the muscular disc and the long bristles already mentioned. In this curious position they wave their short legs vigorously, and sometimes leap into the air. By this means they may attach themselves to the body—often to the feeler—of some passing insect. The Currant Aphids, which wander slowly about the bushes, waving their feelers as they go, serve frequently to convey the mites to the new buds.

Soon after their entry into the new buds, the mites lay their eggs, and multiply largely until the end of summer. The population may become so congested that many mites have to leave the buds during the autumn and winter. According to Warburton, these perish, as they cannot survive on the bushes, under bark, or in the soil; but those that remain in the swollen buds seem unaffected by any degree of cold. Buds which I had the opportunity of examining in December were full of vigorous and healthy mites. Of course a large proportion of these would fail to enter new buds the next spring, and it is during the migration period in May and June that their numbers are at the lowest point.

Knowledge of these facts should enable fruit-growers to deal effectively with this serious pest. Spraying is useless except during the migration period of the mites (May and June), when they are wandering on the bushes; and spraying might then be thought objectionable on account of the blossoms. Applications to the soil are useless, as the mites do not live there. The thorough removal and burning of the galled buds during winter either by picking or severe pruning should ensure freedom from the attack next spring, unless there be other centres of infestation near. Warburton suggests the cutting back of the young growth with the new buds just before the period of migration; but the destruction of the old buds in winter seems an equally certain and less expensive remedy. In very bad cases the total destruction of infested bushes should be ruthlessly carried out. The great point, however, is to prevent the introduction of the mite by rigorously refusing galled stock or cuttings therefrom.

The Peach Aphid.

Aphis persicæ, Fourc.

Leaves of Peach badly affected by these Aphids were received in September from Belfast. The insect, figured by Buckton (3) under the name of *A. amygdali*, is of a rich yellow or brown colour, with black, transverse stripes and lateral spots.

The Cherry Aphid.

Myzus cerasi (Fab.).

Specimens of the Cherry Aphid were received from County Longford in June. The insect is figured by Buckton (2). The various forms of the female are black, with the legs partially yellow, while the male has a yellow, black-striped hind-body. According to Buckton, these aphids are most numerous at two periods of each year—in June, and again in October. The effect of their presence in large numbers is to dry the leaves up "as if scorched by heat."

Nothing more effective than the application of paraffin emulsion can be suggested for destroying these Aphids.

The Garden Chafer.

Phyllopertha horticola (Linn.).

Specimens of this well-known beetle were received in June from County Clare with the information that the species had been excessively common in some localities there since 1895, and that the beetles had done much damage by eating the leaves of Cherry and Plum trees, and the flowers of Roses, as well as by gnawing at young Apples. The practice of these chafers thus attacking immature fruit is mentioned by Ormerod (13, p. 30). These beetles fly actively in the sunshine, but they often rest on the leaves of trees in the early morning, and in the cool of the evening; then they can be shaken down on to boards and sheets, and killed by crushing, or by the application of boiling water. The grubs of these chafers live underground for two or three years, and feed on roots.

OSIER INSECTS.

The Willow Scale-Insect.

Chionaspis salicis (Linn.).

In October shoots of Osier were received from Letterfrack, County Galway, covered with female scales, which Mr. R. Newstead of Chester has kindly identified as belonging to the above species. It has been fully described and figured in the first volume of his recent "Monograph of the British Coccidæ" (10). The appearance of these scales, crowded together on the twigs, can be seen from the accompanying illustration (Plate XXII. 2). They burrow beneath the epidermis of the shoot, and their presence in large numbers, on account of the sap which they withdraw from the wood, makes it brittle, and of little value for basket-making.

Paraffin emulsion applied, if practicable, with a brush, otherwise by spraying, will probably be found the most serviceable insecticide for use against these bark-sucking scales. Newstead recommends that the ingredients should be mixed in the proportions of half a pound of soap with two gallons of paraffin and one gallon of soft water. The soap should be boiled in the water and the oil added while the solution is still hot, and the mixture vigorously churned up with a syringe until it becomes white and creamy. Nine times the quantity of hot, soft water should be added to the emulsion, and the dilution again churned up with a syringe, and applied with a stiff brush during the winter months.

PINE INSECTS.

The Pine Weevil.

Hylobius abietis (Linn.).

This well-known beetle was reported to me in February as having barked young Larch-trees over an area of seventy acres near Fermoy.

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EXPLANATION OF PLATES.

PLATE XXI.

FIG.

1. Frosted Orange Moth (*Gortyna ochracea*). Natural size.

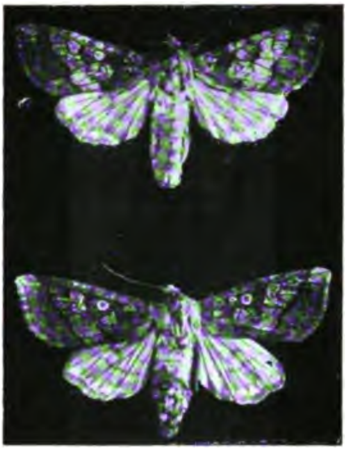
2. Caterpillar in Potato Stem, Male and Female. Natural size.

PLATE XXII.

1. Garlic injured by Rhizoglyphus. Reduced.

2. Osier twig infested by *Chionaspis salicis*. Natural size.

[From Photographs by T. Price.]



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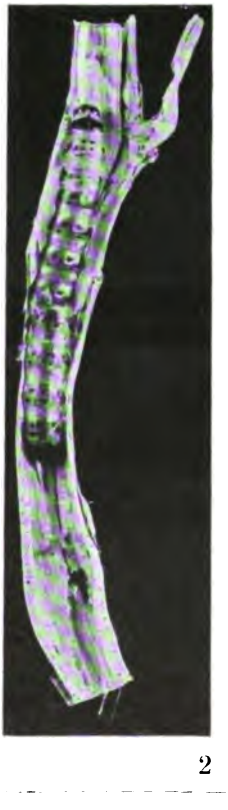

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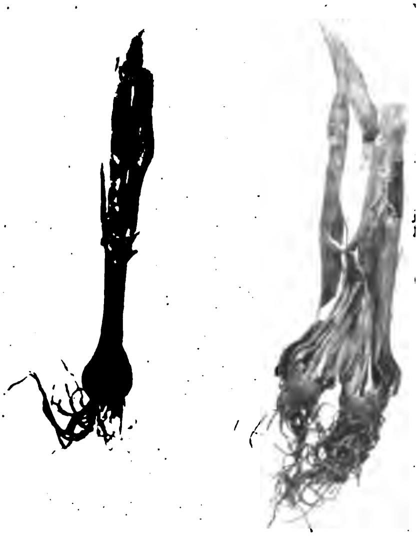

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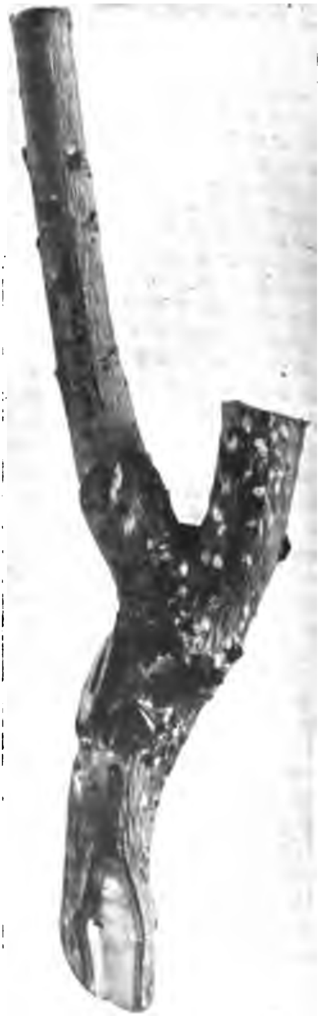

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XIII.

A METHOD FOR THE MECHANICAL ANALYSIS OF SOILS.

By T. CROOK, A.R.C.Sc.I.,
Assistant in Geology, Royal College of Science, Dublin.

[Read, June 21; Received for Publication, June 24; Published, August 12, 1904.]

The subject of soil-analysis is one on which there has been of late much controversy among scientific agriculturists. The point disputed is the use of chemical analysis in enabling us to judge the agricultural value of a soil. It was formerly inferred that if certain chemical elements were present in a soil, growing plants would be able to make use of them. Experiments prove, however, that the interstices between the solid particles of a soil may be so locked up that it is impossible for water to circulate, in which case a plant may starve in the presence of a plenteous store of mineral food, which is almost, if not quite, unavailable.

A consideration of this fact has led certain extremists to the conclusion that chemical analysis is absolutely useless as an index to the value of a soil; and that the only correct way to analyse a soil is to do it mechanically, *i.e.* to divide it into various grades of particles according to size. Perhaps no one would nowadays rely entirely on chemical analysis in judging a soil. Because, even assuming that, as indicated by analysis, a soil contains all the essential elements of mineral food, the question arises—*Is that food available to the plant?* This question can only be answered by an appeal to the physical properties of a soil. It seems reasonable to admit, however, that chemical analyses are useful if they be considered in relation to those properties.

As a guide to physical properties, it cannot be doubted that a mechanical analysis is of extreme importance, especially as indicating the proportion of the finest ingredients, which make a soil impervious. Hence arises the necessity of having a convenient method whereby we can divide a soil into grades of varying sizes. In seeking out such a method, I have come by a process which has some features peculiar to itself, and which it is the purpose of this paper to describe.

The methods at present in vogue for making quantitative separations of the finer grades of soil-particles may be classed in two groups:—

1. Those depending on subsidence in still water, and decantation after standing awhile.
2. Hydraulic methods, in which separation is effected by water currents of varying speeds.

The principle of subsidence and decantation does not offer much scope for variety in method of application. Osborne was the first to apply it in a genuinely scientific manner, and in good hands his method is undoubtedly a very efficient one. It is, however, extremely laborious. It involves fractional separation, along with repeated examination and measurement of particles with the microscope. On account of its tediousness, and the worrying observations that it necessitates, Osborne's method is not inviting, in spite of the fact that it is a very simple one.

The principle of hydraulic separation offers much more scope for variety in its application. The earliest methods, such as those of Nöbel, Dietrich, and Masure, were not quantitative in the true sense of the term. They did not involve the use of definite speeds of flow; and the measurement of particles to determine limiting sizes in the grades obtained was deemed unnecessary.

Schöne was the first to apply the hydraulic principle in a definitely quantitative manner.[1]

The elutriator which he used (see fig. 1) is cylindrical in its upper part, and conical below. The cylinder *C D* is placed vertically, and is long enough (10 cm.) to ensure a uniform speed for a suitable distance with ordinary rates of flow. The elutriator is continued as a tube of uniform bore from *B* to *A*, with a semicircular bend at *B*. It is connected at *A* with a fixed level water reservoir, the connecting tube having a stop-cock, by means of which the water-supply can be regulated. At *D* the elutriator has a flattened or rapidly sloping shoulder, and a narrow neck in the middle. The neck is supplied with a singly-bored rubber stopper, into which is fitted a "piezometer." This piezometer is bent twice at its lower end, and has an outflow aperture at the bend *F*. Above the outflow aperture the piezometer extends vertically for some distance, and is graduated.

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[1] Bulletin de la Société des Naturalistes de Moscou, tome 40.

A good account of the Schöne process is given by Dr. K. Keilhack in his "Lehrbuch der Praktischen Géologie," 1896.

An excellent comparative account of various methods of mechanical analysis is given by Wiley in his "Principles and Practice of Agricultural Analysis," vol. 1. Soils.

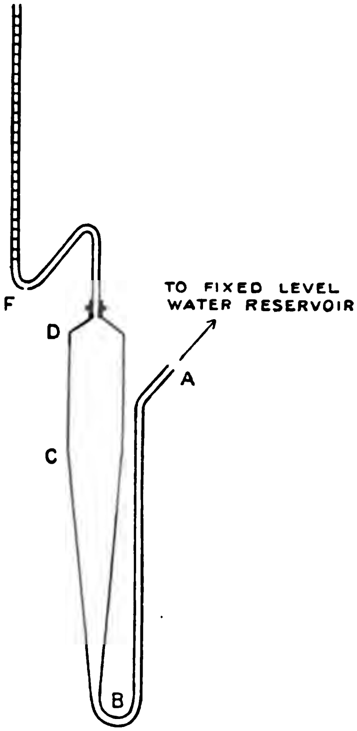

Fig. 1.

The apparatus is standardised in terms of heights of water registered on the piezometer during outflow through the aperture at *F*. The rate of outflow which is necessary to yield a required speed in the cylindrical portion of the elutriator can easily be calculated, and the height of the water-column in the piezometer, corresponding to this rate of outflow, can be found by trial and kept for reference.

There are several modifications of this apparatus. Orth uses a second cylinder (auxiliary cylinder), which has half the diameter of the first; the material is washed in the auxiliary cylinder before entering the larger one. By using these two together he is able to get a greater variety of speeds. The extra trouble involved in standardising by this method is, however, a great disadvantage. This and other modifications seem to increase the complexity and expense of the method out of all proportion to the advantages they yield.

The Schöne method suffers from two serious defects. Firstly, the piezometer is too easily broken at the bend where the outflow aperture is placed, and on this account its use is not very practicable. In this respect, the use of a straight piezometer, and a separate tube for outflow, as adopted by Mayer, is a decided improvement. Secondly, the operation of standardising is tedious; especially so in the case of low speeds, which are estimated by counting drops.

The above defects are apt to discourage the average worker, and at times positively obstruct the work. It is very desirable that some simpler and more economical method should be devised which will yield good quantitative results with a minimum of trouble. It is especially desirable in the case of College laboratories, where lack of manipulative skill on the part of students means much risk of destruction, with its attendant expense and loss of time.

It is unfortunate, too, that at the present time descriptions of quantitative hydraulic methods are cumbered to an unnecessary extent with mathematical equations. These equations are very ornamental, but for the most part they only afford approximations which can be far more quickly and effectively secured by experimental trial. Anyone who understands the simple fact that the volume of a cylinder is equal to the area of cross-section multiplied by the length of the cylinder, can master completely the use of hydraulic methods of analysis. In view of this fact, it seems unnecessary to seek out expressions whose only virtue appears to lie in their complexity.

The following method, which is at present in use at the Geological Laboratory of the Royal College of Science, Dublin, is the outcome of an attempt to simplify the Schöne process, without sacrificing accuracy. In this method no piezometer is used, and standardising is effected by varying the size of the outflow aperture and the head of water.

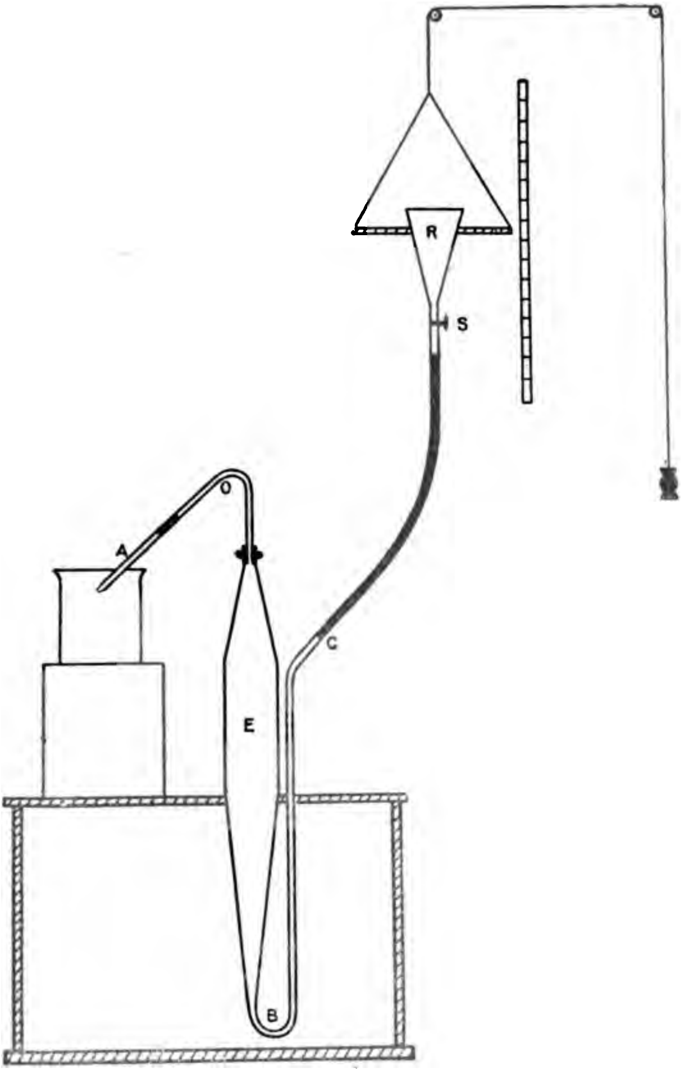

Fig. 2.

The apparatus consists of three parts:—

1. A water-reservoir *R* (see fig. 2), which is fitted to a movable board, the height of which can be varied by a pulley arrangement. The water in this reservoir must be kept at a constant level for any given height. Perhaps the simplest way of securing this is to supply water by a tube connected with a water-tap, and siphon off the excess. The reservoir should have a horizontal mark for a level guide; such a simple arrangement has the advantage of being easily fitted up; but other devices will suggest themselves to the operator, and he must choose one to suit his convenience. The reservoir-tube has a stop-cock *S*, by means of which the water can be turned on or off as required. The reservoir is connected with the elutriator at *C* by means of rubber tubing. This tubing must be long enough to allow for the reservoir being raised when increasing the head of water. It is convenient to have on this tubing near *C* a screw pinch-cock, by means of which the amount of water entering the elutriator can be readily controlled; this pinch-cock proves very useful when siphoning off the residue left in the elutriator.

2. The elutriator, *E*, should differ from the Schöne pattern in having a conical form above as well as below the cylindrical portion. The use of an elutriator with a flat or sharply-curving shoulder tends to yield irregular currents in the cylinder, instead of a uniform upward current, especially for low speeds. This can be remedied by making the upper part of the elutriator conical, and about ten centimetres long. The cylinder should be set as nearly as possible in a vertical position. The following are the most convenient dimensions for the elutriator[1]:—

Length of the cylindical portion,	10 cm.
Length of the upper conical portion,	10 „
Length of the lower conical portion,	50 „
Internal diameter of cylinder,	5 „
Internal diameter of tube *B* to *C*,	5 mm.

Neck of the elutriator, 2 cm. long and 1·5 cm. internal diameter. The neck should be strong, and ground on its inner surface.

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[1] Elutriators of these dimensions can be had from C. L. Müller, 6 Orange-street, Red Lion Square, London, W.C., at *5s.* each.

3. The outlet-tube consists of two parts. The part *O* is a piece of ordinary delivery tubing about 15 cm. long, bent at the middle. This is fitted into the neck of the elutriator by means of a rubber stopper. The part *A* also consists of a piece of delivery tubing, 5 or 6 cm. long, and has a constricted aperture at one end. The aperture can be readily constricted to any required size by drawing out a tube in a Bunsen flame, breaking with a file, and fusing the broken end till by trial the aperture is found to be of the required size. The unconstricted end of *A* is fitted on to *O* by means of a piece of rubber tubing.

Notes on the Elutriator.

The object of the lower conical portion of Schöne's elutriator is twofold: (*a*) to secure a gradual decrease in the velocity of the rising current; (*b*) to produce an agitation among the soil particles for the purpose of separating them; this agitation goes on most effectively at the part near the bend, where the current is comparatively rapid.

The object of the cylindrical portion is to secure a uniform speed in the rising current. For uniform speeds there is a fairly definite, determinable relation between the speed of the current and the maximum size of the particles carried out of the cylinder. Assuming the particles to be globular grains of quartz, there is a limiting size below which they are carried off, and above which they fall in the current. This fact enables us to make a fairly accurate separation of particles above and below a certain limiting size, provided that we make the cylindrical part of the elutriator long enough to permit the particles to lose the momentum which they acquire in the lower conical part.

By using various speeds, and observing the maximum size of globular quartz grains carried off by them, we can establish, once for all, the maximum corresponding to any particular speed. This maximum, however, depends upon the shape and density as well as on the bulk of the particles. Soils are not made up entirely of quartz grains; and soil particles are not by any means all globular in shape. Flakes of mica and particles of humus are carried off much more readily than globules of quartz of the same mass, while grains of hornblende, tourmaline, &c., are not carried off so readily, because of their greater density. It must be remembered that this involves some error, the degree of which depends upon the mineral composition of the soil; but in general, this error is extremely small. In any case it does not appear possible to eradicate it by any practicable method. Fortunately the great bulk of a soil generally consists of granular quartz, so much so that we are justified in using globular quartz grains as standards in estimating the maximum size of particles corresponding to any particular speed of flow. Humus is the commonest and most serious source of error. For this reason, mechanical analysis is always more exact when applied to sub-soils than it is when applied to surface-soils. For the same reason, apart from its value in other respects, the percentage of organic matter in a soil should always be stated along with the results of mechanical analysis.

The following are three useful grades into which fine soil particles are commonly divided, and the speeds by which they are obtained, globular quartz grains being used as standards:—

Grade.	Speed.
Particles up to 0·01 mm. diam.	0·2 mm. per sec.
„ from 0·01 to 0·05 „ „	2·0 „ „
„ from 0·05 to 0·1 „ „	7·0 „ „

It is advisable to place a quantity of small shot at the bottom of the elutriator in carrying out an analysis, otherwise some of the soil collects in a lump on the side opposite to that where the water enters the lower conical part, and thus escapes elutriation. It is not advisable to use mercury for this purpose, as it breaks up too readily, and tiny globules escape when siphoning off the residue from the elutriator. The shot must be regarded as a permanent part of the apparatus; it should be put in before standardising, and need not be taken out in the process of analysis.

STANDARDISING THE APPARATUS.

When the elutriator and outlet-tube are full of water and free from air-bubbles, and water is escaping under pressure from the aperture of A, the water rises through the cylindrical portion of the elutriator with a uniform speed. This speed depends upon three things:—

1. The area of cross-section of the cylinder.
2. The size of the outflow aperture.
3. The head of water.

We can measure the area of cross-section of the cylinder, and knowing this area, we can determine how much water must flow out per second to give us a required speed. This amount of outflow can be secured by making an aperture of suitable size and varying the head of water.

To find the area of cross-section of the cylinder, make two horizontal marks on the cylinder a few centimetres apart (two strips of gummed paper will do). Pour in water till the lower meniscus of the water-surface stands at the upper mark. Then take out water by means of a pipette till the surface falls to the lower mark. The volume of water thus taken out can be measured in a graduated vessel, and since the volume of water filling the portion of the cylinder between the two marks = height × area of cross-section, we have:—

$$\text{Area of cross-section} = \frac{\text{volume}}{\text{height}}.$$

A note of this area must be kept with the cylinder.

To obtain any required speed.

Suppose we wish to obtain a speed of x mm. per second in the cylindrical portion of the elutriator, the area of cross-section being A sq. mm. Since the volume of outflow is equal to the speed multiplied by area of cross-section, it follows that, to get a speed of x mm. per second, we must have $A \, . \, x$ cubic millimetres flowing out per second, that is—

$$\frac{A \, . \, x \, . \, 60}{1000} \text{ cubic centimetres per minute.}$$

All we have to do then is to make an outflow tube, with a constriction small enough to give approximately this outflow, and to vary the head till we get exactly the outflow required. The rate of outflow is determined by catching the water in a graduated vessel. It will require a few trials before the proper size of aperture is obtained, but once obtained there is no fear of breakage with ordinary care, and the cost is a mere trifle. One of these outflow tubes can be made for each speed required, and they are most readily exchanged in the course of analysis. The various outflow tubes should be kept in separate labelled trays, and along with each there should be a note as to the head required to yield the particular speed corresponding to it. It will be found that no constriction at all is necessary when using a speed of 7 mm. per second, provided that the outlet tube has an internal bore between 4 and 5 mm. in diameter. An aperture of about 1 mm. dia. will be required for the speed of 2 mm. per second, and one of about ·5 mm. dia. for the speed of ·2 mm. per second, the range of head being from 1 decimetre to 2 metres.

SCHEME FOR THE MECHANICAL ANALYSIS OF A SOIL.

There is a tendency at present to neglect the coarser constituents of a soil in making mechanical analyses. It cannot, however, be too strongly emphasized, that the object of a mechanical analysis is to serve as a guide to the structure and physical properties of a soil as it exists in nature, and not merely as it exists after having passed through a fine sieve in the laboratory.

On the other hand, it is customary to give a considerable amount of detail in dealing with the finer constituents. The question as to the number of grades into which a soil should be divided is, of course, to some extent arbitrary, and depends much on the character of the soil. In any case, it is well to remember that mere detail in itself is useless, and is only valuable in so far as it enables us to predict or understand peculiar physical properties, such as air space, water capacity, permeability, &c. In the majority of cases, a simple analysis into four or five grades will furnish all the information necessary, while giving far less trouble than more elaborate analyses.

The following scheme aims at giving a simple and complete mechanical analysis, from which a fairly definite idea can be formed as to the structure and physical properties of a soil:—

(i.) Take a few kilograms of soil from a typical position; spread it out on a thick sheet of paper, and let it dry in the air. When dry, pick out all the stones larger than 5 cm. in diameter. In an ordinary soil these will not be numerous, and their distribution is so irregular, that exact quantitative determination is unnecessary. Their presence or absence in the soil is, however, a matter of importance to the cultivator, and they should be accounted for in any analysis that pretends to be complete. They should be washed, dried, and weighed, and their proportion to the whole soil should be estimated approximately.

(ii.) Take a kilogram of the soil from which stones larger than 5 cm. diameter have been picked out, and sift through a sieve the holes of which are 1 cm. diameter. Wash, dry at about 90° C., and weigh the stones remaining on the sieve.

(iii.) Take 500 grammes of material which has passed the 1 cm. sieve, and sift on a sieve with circular holes 1 mm. in diameter. Preserve the material passing this sieve for the purpose of elutriation. Wash the material remaining on the sieve. Dry and weigh.

(iv.) Take 20 grammes of the material (dried at 90° C.) which has passed the 1 mm. sieve. Boil in a porcelain dish for one hour, with constant stirring and gentle pestling with a rubber-tipped glass rod, so as to break up the clots of clay. Prolonged boiling is necessary in the case of clayey soils. Place the boiled soil in the elutriator. For this purpose a glass funnel is placed in the neck of the elutriator, and the soil is washed out of the porcelain dish by means of a wash-bottle. Adjust the apparatus to yield a speed of 0·2 mm. per second in the cylinder of the elutriator. With this speed all the clay is washed out, including particles up to 0·01 mm. in diameter. If it be desired to estimate the clay directly by weighing, these washings must be preserved. It is much less troublesome to estimate the clay by difference, in which case the clay washings can be thrown away.

(v.) When the water in the cylindrical portion of the elutriator becomes clear, which will take about three hours with a loam, and six or seven with a clayey soil, stop the flow, and adjust the apparatus to yield a flow of 7 mm. per second. This washes out all the particles from 0·01 up to 0·1 mm. diameter. This grade we may call silt. These washings are caught in a beaker, and are most readily secured by filtering. The residue is afterwards dried in a bath at about 90° C., and weighed.

(vi.) The residue now left in the elutriator consists of particles from 0·1 to 1 mm. diameter. This residue we may call sand. It can easily be drawn off from the elutriator by siphoning. This operation is more easily effected if a slight current of water be turned on, so as to agitate the particles at the bottom of the elutriator. For this purpose, it is very handy to have a screw pinch-cock on the tube, which connects the elutriator with the reservoir, as already mentioned. This residue is also dried and weighed.

In this way we obtain :—

(*a*) Big stones larger than 1 cm. in diameter. These are picked out by the hand from a large bulk of soil, and it is convenient to state separately their proportion to the whole soil taken.

(*b*) By sifting :—

Stones (5 cm. to 1 cm. diameter).
Gravel (1 cm. to 1 mm. diameter).

(*c*) By elutriation :—

Sand (1·0 mm. to 0·1 mm. diameter).
Silt (0·1 mm. to 0·01 mm. diameter).
Clay (0·01 mm. and less).

STATEMENT OF RESULTS.

In stating results, the composition of the elutriated portion of the soil, including particles up to 1 mm. diameter, may be stated separately :—

		After ignition.
Sand, .	x grammes.	s grammes.
Silt, .	y „	t „
Clay, .	z „	v „
Total	20 „	

If the clay has been obtained by difference, the organic matter must be estimated by igniting a separate sample of 20 grammes, after drying at 90° C. The loss on ignition represents organic matter mainly, though it includes some moisture, and also carbon dioxide when carbonates such as limestone are present.

From the foregoing data, the composition of the whole soil, excluding stones larger than five centimetres diameter, can be readily calculated, and is conveniently made up to a thousand parts, thus :—

Stones, .	l	grammes,	separately determined; includes roots.
Gravel, .	m	„	
Sand, .	n	„	determined on a sample of 20 grammes, including organic matter.
Silt, .	p	„	
Clay, .	q	„	
	1000	grammes.	

From results thus stated, we can, in any particular case, form a moderately definite idea of the way in which a kilogram of soil is built up. We can also tell much concerning its physical properties, and predict to some extent its consequent agricultural value.

I am very much indebted to Professor Cole and Professor Wilson for advice very kindly given to me while preparing this paper.

XIV.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1904.

By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Professor of Zoology in the Royal College of Science for Ireland, and Consulting Entomologist to the Royal Dublin Society.

(Plates XXIII.–XXVI.)

[Read, April 18; Received for Publication, April 20; Published, August 26, 1905.]

CORN INSECTS.

Crane-Flies.

Tipula oleracea, Linn., and other species.

The destructive "Leather-jacket" grubs of these flies continue to attract notice by their ravages in the roots of cereals. In the month of May I was informed that a whole field of Oats at Sutton, County Dublin, had been ploughed up on account of the irreparable injury done by these grubs. I further received numerous specimens from County Derry, where they had also been injurious to Oats.

A description of the life-history of these insects, with notes on the means which have been suggested for preventing and checking their ravages, may be found in my previous papers (3, 1902–3). During the past year a leaflet (No. 51) on the subject was issued by the Department of Agriculture and Technical Instruction. This leaflet—besides laying stress on the importance of closely grazing pastures that are to be broken up, clearing away rank growth by rough mowing, and letting a potato crop be grown before an oat crop—states that "the use of agricultural salt applied at the rate of 3 cwt. per statute acre about three weeks before sowing the seed is beneficial, particularly if the young plants be fortified against attack by a suitable mixture of artificial manures." Stress is also laid on effective ploughing—" Bad ploughing very much favours the attack, particularly when the grass is not properly turned down. In this connexion the Department strongly urge the universal use of ploughs with an effective skim-coulter, when grass-land is ploughed preparatory to sowing Oats." A correspondent in County Derry recommends the application of salt to the lea about two months before ploughing, the salt being worked into the grass-land by chain-harrowing and rolling.

Some laboratory experiments, which I tried during the summer with a large number of the grubs, showed that they succumb rapidly when powdered naphthalene is mixed with the soil, or a very dilute solution of formalin (3 per cent.) applied. It would be desirable to try similar experiments in the field on a large scale. Some insecticides for mixture with the soil are now on sale, and might prove effectual against Crane-fly grubs and other root-feeding insects.

The Frit-Fly.

Oscinis frit (Linn.).

Oats from County Down damaged by the maggots of this fly were recorded in July. An account, with figures of the insect, is to be found in my paper on Injurious Insects observed during 1902 (3, 1902, pp. 147–8).

The Gout-Fly.

Chlorops tæniopus, Meig.

Specimens of Barley infested by the maggots of this fly were sent from Crossabeg, County Wexford, in July. Although a well-known insect, and doubtless widely spread in Ireland, I have not previously received evidence of its ravages in this country. Repeated references to the insect are to be found in Ormerod's "Reports" (9, 1877, 1878, 1879, 1880, 1882, 1885, 1887, 1888, 1889, 1890, 1892, 1893, 1894); and an excellent short account of its life-history has lately been given by Theobald (15, pp. 23–5); while a fuller description may be seen in Ritzema Bos' work (2, pp. 625–8).

Chlorops tæniopus is a small two-winged fly, measuring about 4 mm. ($\frac{1}{6}$ inch) in length and 6 mm. ($\frac{1}{4}$ inch) across the outspread wings. The flies of this genus—all small in size—are characterised by their prevailing black and yellow colouring, the sparse covering of hairs or bristles on the cuticle, the relatively short and broad wings, and the flattened circular shape of the third segment of the feeler (fig. 1, *b*). In *C. tæniopus* the head is yellow, with a central, triangular, black marking, the feelers being entirely black; the fore-body is yellow, with three broad, black, longitudinal stripes above, and a short, narrow stripe on either side, the scutellum being yellow; the hind-body is yellow, with somewhat obscure dark-brown transverse markings; the thighs and shins of the legs are entirely yellow, except that the fore-shins are black-tipped; the fore-feet of the female are entirely dark; those of the male have the basal and two terminal segments dark. The middle and hind feet in both sexes have the three basal segments yellow, and the two terminal segments dark (fig. 1, *a*). The tail-end is rounded in the male, and pointed in the female.

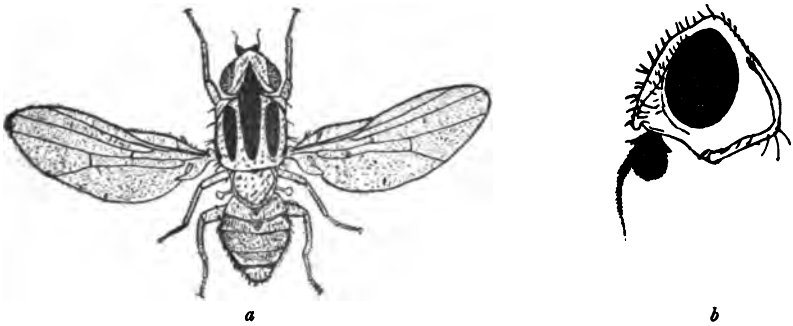

Fig. 1.—(*a*) Gout-fly [*Chlorops tæniopus*, Meig]. Male: × 8. (*b*) Head seen from the side: × 20.

These flies are on the wing late in May or in June. The female lays her eggs (which are elongate, oval, of a creamy-white colour, with a honeycomb-like pattern on the upper surface, and a wide longitudinal groove beneath) singly or in couples, on the outer leaves of young corn-plants, choosing those plants in which the ear is still completely enveloped by the sheathing-leaves. The young maggot, when hatched from the egg, makes its way beneath the sheathing-leaves to the haulm, which it proceeds to attack. Beginning with the lower part of the ear, or the stalk just beneath, the maggot works its way down a channel towards the first node. The presence of the maggot often stops the growth of the plant, so that the ear remains enclosed within the sheathing-leaves, and the shoot shows a characteristic "gouty" swelling. When the haulm grows to anything like its proper length, the ear is stunted, and the grain comparatively worthless. The fully-grown maggot is 6–7 mm. ($\frac{1}{4}$ inch) in length.

Late in June, or early in July, the maggots pupate; the brown puparium is usually to be found at the bottom of the furrow which the maggot has gnawed down the stem, but occasionally between the sheathing-leaves and the damaged ear. The flies come out during August, September, and October, when they pair and lay their eggs on winter corn or wild grasses. The maggots hatched from these eggs make their way inside the sheathing-leaves, and thence to the summit of the undeveloped shoot, where they pass the winter. The effect of their presence is to reduce the normal length of the stalk, while the base of the plant swells enormously, and the sheathing-leaves become excessively broad. The flies produced from these maggots lay eggs on the Barley and other cereals in spring and early summer, as described above. Thus there are two complete life-cycles in the year (Theobald, 15; Ritzema Bos, 2).

The concealed feeding-habits of the maggots render their destruction by insecticides impossible. Nothing can be recommended for an attacked crop except the application of manure to stimulate growth. But our knowledge of the life-history of the fly suggests several practicable methods of prevention. Early-sown corn suffers but little from the summer attacks of this insect, because, before the spring brood of flies appears, the young plants have passed the stage appropriate for egg-laying. Barley badly affected by this pest is always found to have been sown late. On the other hand, when winter corn is grown it should be sown late, so that the autumn brood of flies may find no young plants ready for egg-laying. When no corn is available, the flies lay on wild grasses; hence grassy headlands should be cut and burnt in winter. Lastly, the refuse from an attacked crop, after threshing and stacking, will probably contain many puparia; such refuse should therefore be gathered and destroyed. The flies can sometimes be collected in numbers from stacked corn.

Millipedes.

Polydesmus complanatus (Linn.).

Complaint was received in May of damage to a field of Newmarket Oats in County Carlow by Millipedes of the genus Polydesmus. It was stated that these creatures began to eat the plants at the ground-level, and then travelled down to the roots. A portion of the field, ploughed at a time different from the remainder, was not injured; probably the ploughing had, in this instance, destroyed the eggs. Theobald (14, pp. 86–7) recommends broadcasting lime over the surface, and working it into the soil, or setting traps in the form of hollowed-out mangolds (potatoes would probably be effective also) wherein the Millipedes can be enticed and destroyed.

Stem Eelworms.

Tylenchus devastatrix, Kühn.

Samples of Oats, showing the characteristic "tulip-root" condition due to the presence of these minute thread-worms, were received from County Down in July. This infestation, which has attracted much attention in Great Britain during the last twenty years, seems to have been but little noticed in Ireland. Many references to the worms are to be found in Ormerod's "Reports" (9, 1886, 1887, 1888, 1889, 1890, 1894, 1896, 1897, 1898), and a full account of them is given by Ritzema Bos (2, pp. 733–760), who has paid special attention to the class Nematoda, to which they belong.

Nematode worms may be readily distinguished by their thick, usually smooth, transparent cuticle, their whitish colour, and the absence of the segmentation and bristles which characterise the Ringed-worms or Annelida. There is a powerful muscular pharynx and narrow gullet, formed by an inpushing of the body wall with its outer skin and cuticle ; this is followed by the flattened intestine, whose walls are without any muscular tissue, ending at the anus situated near the hinder end of the body. The sexes are separate, and the genital organs are long and tubular in form ; the vas deferens of the male opens close to the anus ; but the vagina of the female is always situated in front of the anus.

The Eelworms, or Anguillulidæ, are a family of Nematodes, distinguished by their very small size, the presence of two swellings in the gullet (fig. 2, *g.*), and of two spicules (fig. 2, B, *sp.*), equal in size, at the male genital opening. The mouth is frequently armed with a horny " dart " (fig. 2, *d.*) by means of which plant-tissues are pierced and nourishment obtained. The eggs produced by members of this family are comparatively fewer in number than among Nematodes generally, but they are of relatively larger size ; and as they complete their development rapidly, the rate of multiplication is high. Eelworms live in damp earth, and feed on decaying organic matter, or on living plant-tissues. They do not, like most Nematoda, live as parasites on higher animals.

The genus Tylenchus contains a number of Eelworms in which both sexes are slender and elongate throughout life. (In Heterodera —a species of which, *H. Schaachti*, is very destructive to the roots of Sugar-beet, Tomatoes, and Cucumbers—the female becomes swollen and lemon-shaped.) The mouth is provided with a small, sharp, hollow spine, which swells at its hinder end into a three-lobed knob. The ovary (fig. 2, A, *ov.*) and oviduct (fig. 2, A, *ovd.*) of the female are unpaired, and the vagina (fig. 2, A, *va.*) opens behind the middle of the body. The cloaca of the male has a delicate fold of skin on one or both sides, forming a " bursa " (fig. 2, B, *bu.*).

T. devastatrix is a minute worm, measuring from 1 mm. to 1·5 mm. in length. The tail-region, which is markedly narrowed, is about $\frac{1}{16}$ the length of the body. In the female the ovary and oviduct are unpaired, and the vagina opens usually $\frac{1}{5}$ of the body-length, from the tip of the tail. In the male the bursa may be developed all around the cloaca, or on one side only. The species is excessively common, and is to be found on a great variety of

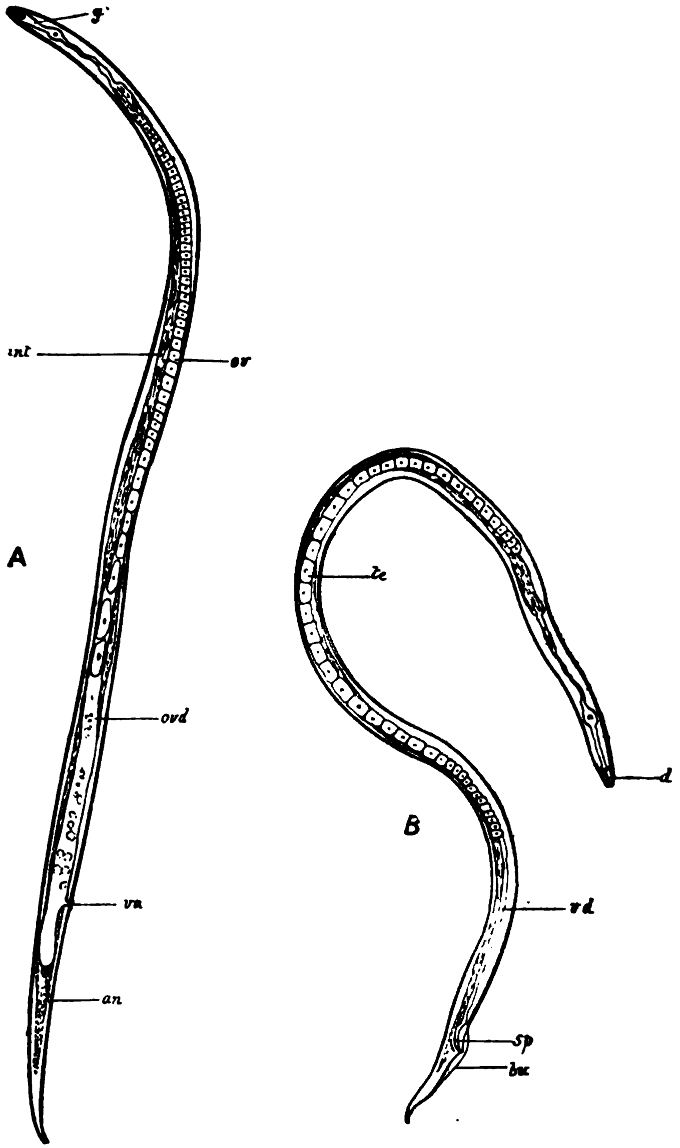

Fig. 2.—Stem Eelworm [*Tylenchus devastatrix*, Kühn]. *A*—Female: × 150. *B*—Male: × 150. *an.* anus; *bu.* bursa; *d.* dart; *g.* gullet; *int.* intestines; *ov.* ovary; *ovd.* oviduct; *te.* testis; *v. d.* vas deferens; *va.* vagina; *sp.* male spicules.

wild and cultivated plants. At different times it has been noticed as injurious to Oats, Rye, Wheat, Clover, Turnips, Hops, Onions, and Hyacinths: in these countries Oats and Clover seem to suffer most severely from its ravages. Ritzema Bos has shown that worms from any particular crop will infest plants of that kind more readily than those of any other kind.

In Oats, when these worms are present, the base of the stem becomes swollen—hence the term "tulip-root"; and stunted and deformed shoots grow around it. The true roots are not attacked, the Eelworms occurring in large numbers within the swollen base of the stem, among the sheathing-leaves surrounding it, and also in the deformed shoots. Their presence leads to an excessive development of the spongy tissue (parenchyma) of the plant, whose cells grow and multiply abnormally, while the growth of the vascular bundles is arrested.

These Eelworms enter young plants, and remain throughout the summer there, feeding and multiplying; several generations succeed one another through the year. When the Oats ripen and become dry, most of the worms leave the plants and go back to the soil, where, in the surface-layers, the young are able to live for more than two years in a state of suspended animation, from which they are temporarily roused when the ground is moistened by rain. Thus the soil is infested after an attacked crop has been reaped; and unless effective measures be taken, the mischief may be carried on from year to year.

The worms cannot live at any great depth below the surface; hence, deep autumn ploughing, with a skim-coulter attached, as recommended above for destroying Crane-fly grubs (p. 282), is an excellent preventive measure for this disease also. In rotation, two crops both subject to the attack of these worms should not succeed each other—for example, Oats and Clover. As a remedial dressing, sulphate of potash, to the amount of 1 cwt. to the acre, has been found effectual; a mixture of sulphate of potash (2 parts), sulphate of ammonia (3 parts), and phosphates (4 parts), applied to the amount of 1¼ cwt. to the acre, has also been recommended.

CABBAGE AND TURNIP INSECTS.

The Root-Fly.

Phorbia brassicæ, Bouché.

Cabbages at Glasnevin, County Dublin, were badly attacked in the summer by the maggots of this fly, described somewhat fully by me in a previous paper (3, 1901). Unfortunately the effective methods for preventing the egg-laying of the fly, and for destroying the maggots, have been pronounced uneconomical by Irish farmers; and experiments with the view of finding a practical remedy for this serious pest are badly needed.

MANGOLD INSECTS.

The Mangold-Fly.

Pegomyia betæ (Curtis).

Plates XXIII. and XXIV.

This well-known fly attracted very much attention throughout Ireland during 1904. Complaints of the damage done by its leaf-mining maggots were received from numerous localities, so widely apart as Counties Antrim, Derry, Armagh, Sligo, Kildare, Wicklow, Wexford, and Cork; and the attack was noticed from June until September.

The female fly lays her eggs in clusters, usually of eight or nine, beneath the leaves. The eggs are white, elongate, oval, about 1 mm. in length, and showing a characteristic sculpture on the surface (Plate XXIII., figs. 1, 2). The young maggot, as it is hatched from the egg, makes its way directly into the leaf, and burrows beneath the upper and lower leaf-skins, devouring the soft, green tissue as it goes along. As a number of the maggots grow in size, the mines, at first narrow, are widened out, so that the leaf-surface becomes largely covered with yellow or brown blisters, partially filled with the black excrement of the maggots. Ultimately the leaves droop and fade, so that a mangold-field badly attacked by these insects presents a withered and forlorn aspect. (Plate XXIV.)

From the amount of material sent in by different correspondents, I have been able to study various stages in the development of the maggot. The newly-hatched maggot is 1·4 mm. long (Plate XXIII., fig. 3); its mouth-hooks are comparatively simple, the basal sclerite having the dorsal process single (fig. 3, *a*); each tail-spiracle has a single, rounded opening constricted in the middle (fig. 3, *b*, *c*). At its next stage (fig. 4) the maggot is 2 mm. long, with the mouth-hooks already (fig. 4, *a*) closely resembling those of the full-grown grub (compare figs. 5, *a* and 6, *a*); the tail-spiracle now shows two distinct oval openings (fig. 4, *b*, *c*); at this stage there are some rather prominent spines on the ventral aspect of the third and fourth trunk-segments. When the maggot is 6 mm. long (fig. 5), probably two moults after the 2 mm. stage, these spines are distinctly less prominent; the prothoracic spiracle (fig. 5, *b*) with seven branches is now conspicuous, and the tail spiracle has three openings like that of the adult (fig. 6, *d*). The full-grown maggot (fig. 6) measures from 8 to 10 mm. in length. Its much-wrinkled skin is beset with very minute spines; the tubercles surrounding the tail spiracles are small and inconspicuous (fig. 6, *c*), and each spiracle has three broadly oval openings (fig. 6, *d*). The prothoracic spiracle now possesses from eight to ten branches (fig. 6, *b*). Evidently the maggot resembles closely that of *Pegomyia vicina*, Lintner, described and figured by Howard (4, pp. 50–52).

The maggots appear to pass through their various stages in two or three weeks, the rich nature of their food enabling them to grow rapidly. When fully fed, the larval skin hardens to form the dark-brown, barrel-shaped puparium (fig. 7) which protects the delicate pupa. The puparium is usually found just beneath the soil surrounding the plants, but sometimes pupation takes place within the leaf-blister. There are successive broods of flies through the summer, and the ravages of the maggots are sometimes found to recur every three or four weeks. The winter is passed by the insect as a buried pupa.

The Mangold-fly, like the flies that give rise to the Cabbage-root maggots, belongs to the family Anthomyiidæ. Its genus Pegomyia agrees with Phorbia, the genus of the Cabbage-flies, in the equality of the two rounded scales at the wing-base, but differs in that most of its species have the legs largely yellowish, instead of black. *Pegomyia betæ* measures about 5 mm. in length, and 12 mm. across the outspread wings. The female (fig. 8) is an ashy-grey fly with very indistinct longitudinal stripes on the fore-body, and a reddish frontal marking on the head between the eyes. The thighs and shins are yellow, dusky along their outer edges, and the feet are black. In the male the eyes are much larger than in the female, almost meeting in the middle of the head (fig. 9); the body is darker grey, and the thighs are altogether dusky, the shins only being partially yellowish. See Meade (6).

The concealed feeding-habit of these maggots makes it useless to apply any insecticide for their destruction. A certain method of killing the maggots is to remove and burn all the injured leaves; but probably no farmer would undertake such a task over a large field. The usual practice is to apply some stimulating manure, and to wait for heavy rain, which is generally found to check effectually the ravages of the fly. It is often noticed that the large outer leaves of the Mangold-plants suffer badly from the maggots, while the smaller inner leaves remain comparatively uninjured; and, as a rule, it is only when the attack begins early, affecting the young foliage, just after sprouting, that the roots become seriously reduced below their normal size. Such was the experience of Mr. T. A. Rudd, Agricultural Instructor in West Cork, who informs me that the crop was disastrously injured in cases where the attack began early under conditions favourable to the flies.

Crane-Fly.

Tipula oleracea, Linn.

An exceptional case of injury to Mangold-roots by the Leather-jacket grubs (see p. 281) at Enniscorthy, County Wexford, was brought to my notice in June by the editor of the *Farmers' Gazette*. The correspondent stated that these grubs were also injuring roots of Vegetable Marrow plants.

PEA AND BEAN INSECTS, &c.

The Pea-Beetle.

Bruchus pisi (Linn.).

Peas containing pupæ and adults of this well-known insect were kindly sent to me from County Limerick, in December, by Mr. J. O'B. Croke. Beetles of the family Bruchidæ are easily recognised by the feet with four segments, and the head (largely covered by the fore-body shield) bearing short feelers and not prolonged into the snout which is so characteristic of the true weevils (Curculionidæ). *Bruchus pisi* measures 4–5 mm. in length, and is of a black colour, variegated with greyish down, the thighs and feet of the front legs and the feet of the middle legs being red. The hard, case-like forewings (elytra) are ornamented with patches of white, downy hairs, arranged in a wavy, transverse series, while the tail-end of the abdomen is covered with white hairs, so arranged as to leave two conspicuous, rounded, black patches (fig. 3, *e*).

Full accounts of this beetle and the allied forms which attack Beans will be found in the writings of Ormerod (9, 1900, pp. 21–31) and Riley and Howard (10). The beetles are active in early summer when the peas are blooming, and the female lays her eggs on the surface of the young pod. The egg (fig. 3, *a*) is spindle-shaped, deep yellow in colour, 1·5 mm. long, and attached by means of a sticky fluid which turns white on drying. From this is hatched the stout, hairy larva (fig. 3, *b*) with three pairs of short legs, and powerful complex spines on the foremost trunk-segment. It is believed that these spines enable the grub to bore through the pod into a young pea. Usually the grub makes its way directly through into the pea, but occasionally it lives for a time mining in the pod before entering the pea. Having entered the pea, the grub casts its skin and becomes a legless, fleshy maggot (fig. 3, *c*) with very small head. It now proceeds to tunnel in the substance of the cotyledons, often injuring the plumule so as to render germination impossible, and always damaging the seed sufficiently to check healthy growth. These facts are of great practical importance, as dealers sometimes assert that "weevilled" peas and beans germinate as well as uninjured seeds! By autumn the grub is fully grown, and its last act before pupation is to cut a circular passage to the outer skin (testa) of the seed, thus providing a way of escape for the beetle, which, when developed, has only to bite through the circular drum-like membrane left by the grub. This spot is visible as a dark patch on "weevilled" seeds, and Mr. Croke points out to me that it can be rendered more easily visible by soaking. The beetles emerge from the pupa-skins in late autumn or winter; but they remain within the seed till the spring, when they come out to lay their eggs on the new crop of peas or beans.

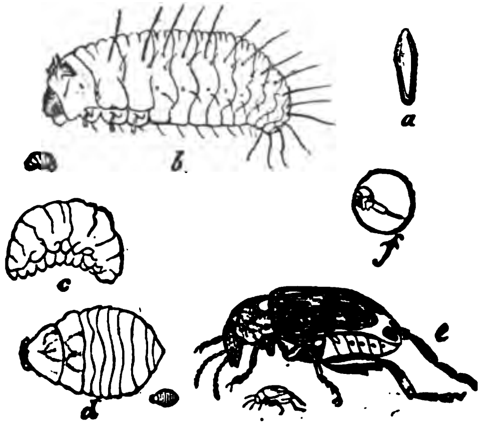

Fig. 3.—Pea Beetle [*Bruchus pisi* (Linn.)]. (*a*) egg; (*b*) young larva: both highly magnified; (*c*) older larva; (*d*) pupa; (*e*) Beetle: × 5; (*f*) injured pea, natural size. From Riley and Howard (partly after Curtis). "Insect Life," U. S. D. Ag., vols. iv., v.

The sure remedy for this infestation is a rigorous refusal to accept or sow "weevilled" seed. Those who use such seed not only get a short and feeble crop, but secure another generation of beetles to damage their own and their neighbours' plants.

Springtails.

Lipura ambulans (Linn.).

Further confirmation has been received of the injurious action of the Springtails mentioned in my paper of last year (3, 1903, pp. 251–3). In June I had the opportunity of examining in a County Dublin garden roots of Kidney Beans badly gnawed by Lipuræ, accompanied by a few specimens of Achorutes. The appearance of roots injured by these Springtails, and the characteristically scraped surface, can be seen in the photograph (Plate XXVI., A).

A New Oribatid Mite.

Lohmannia insignis, Berlese.

Plate XXV.

Associated with the Springtails just mentioned were specimens of a brown mite which was also devouring the root-surfaces. Mr. Cecil Warburton, to whom specimens were shown, recognised the creature as an Oribatid, new to science. Meanwhile, Signor A. Berlese, to whom examples from another locality had been unknowingly sent several months previously along with some Gamasidæ, described and figured the animal as *Lohmannia insignis* (1, pp. 23-4). The genus Lohmannia, Michael (8), is characterised by the cylindrical form of the abdomen, the short, stout legs, each with a single claw, the four foremost and four hindermost being inserted, respectively, close together, and the large chelate mandibles. The dorsal plate of the abdomen is flexed far round on the ventral surface, where it touches the lateral "cover" bounding the anal and genital areas (Plate XXV., figs. 1, 2).

The mites of this genus are lightish-brown in colour, and are remarkable in resembling in aspect the immature (nymph) forms of the more typical Oribatidæ. There are but very few known species of Lohmannia. Michael (8) mentions only two, one German, and the other Italian; a few additional Italian species have since been described by Berlese. Until the discovery of the present mite, the genus was not represented in the British Islands. The observation of Mr. Bell, the gardener who first directed our attention to the mite, is therefore of faunistic as well as of economic importance.

Lohmannia insignis may be distinguished from the other species of the genus by its general form, by the simple bristles on the abdomen, and by the peculiar feathered pseudostigmatic organs

(Plate XXV., figs. 1, 4). These structures protruding from the paired tubular or cup-shaped outgrowths—formerly regarded as the entrances to the air-tube system—on the fore-body of the mite are specially characteristic of the Oribatidæ.

It is of considerable interest to find a small animal like this, hitherto unknown to naturalists, forcing itself on our attention by damaging cultivated plants. All the Oribatidæ are vegetable-feeders, but most of them are found among moss, or in partially decaying wood; and I know of no record of any species being injurious in farm or garden. The most reasonable suggestion seems to be that the presence of an abundant supply of vegetable food in the neighbourhood of a small colony of mites induced them to change their method of feeding, and led to a great increase in their numbers.

POTATO INSECTS.

Small Chafer.

Phyllopertha horticola (Linn.).

Grubs of this well-known beetle were sent in July from Waterford by the County Agricultural Instructor, Mr. J. Johnston, who stated that they were very numerous in the soil around Potato plants suffering from a fungal disease. It is to be presumed that these grubs were devouring the tubers and roots; but it is, I believe, unusual for them to attack Potato.

Spotted Millipede.

Blaniulus venustus, Meinert.

Potato tubers were sent me from Kilkenny in March by Mr. F. W. Moore, of the Royal Botanic Gardens, badly gnawed and tunnelled by small Snake-millipedes of the genus Blaniulus. These Millipedes are easily recognised by their narrow, elongate cylindrical form and their pale-whitish colour, adorned with red spots arranged in series along either side. They are often highly injurious to Potatoes. According to Theobald (15, p. 86), a dressing of lime to land infested with them is the surest remedy, and the plan of dusting soot and lime around each tuber when set has been tried successfully as a means for preventing their attacks.

GARDEN INSECTS.

The Celery-Fly.

Acidia heraclei (Linn.).

During the autumn months of 1904—from September till November—many complaints were received of the damage done by the leaf-mining maggots of this fly to Celery grown in County Dublin gardens.

The fly is included in the same large family of the two-winged flies (Diptera) as the Gout-fly (*Chlorops tæniopus*) already described in this paper. It belongs, however, to a section of the family characterised by a variegated dark pattern on the wings, which in this species are mostly mottled with deep brown, leaving a few transparent spots and patches. The fly is about 6 mm. (¼ inch) long, and of a dark brown or blackish hue, the front of the head and the legs being yellow (fig. 4, *a*). The insect is first on the wing in May, and the female lays her eggs on the leaves of Celery and Parsnip (as well as on many wild plants, such as Cow-parsnip and Dock). The maggot, fleshy and white, or often greenish (because the food shows through the transparent skin), lives, like the maggot of the Mangold-fly, between the two leaf-skins, eating away the soft, green tissue. Its presence is at first shown by a small, round blister paler than the rest of the leaf. As the maggot feeds, moves, and grows, the blister spreads, becoming first white, and then, as the leaf dries up, brown, and choked with the insect's black excrement. Several maggots often feed on one leaf, which may at last wither completely.

Several broods of maggots succeed each other through the summer and autumn. The pupal stage may be passed within the leaf, but more often underground; the puparium (fig. 4, *c*) is very distinctly segmented with deep constrictions between the segments, yellow or light-brown in colour. The latest autumn brood of maggots always bury themselves a few inches deep in the soil for pupation, and the flies from these do not appear till the following spring.

From this fact it is evident that the removal and deep burial of the surface-soil in winter after an attack, or a dressing of gas-lime dug in, would be effectual in preventing a return of the mischief in the ensuing year. In garden cultivation it should be quite practicable to kill the maggots as they feed within the leaves by pinching the blisters, and a watch should be kept for their first appearance. At a later stage the blistered leaves may be hand-picked and burnt; on no account should they be left lying about, as the insect is very hardy, and the maggots often complete their transformations even though the leaves be removed from the plant.

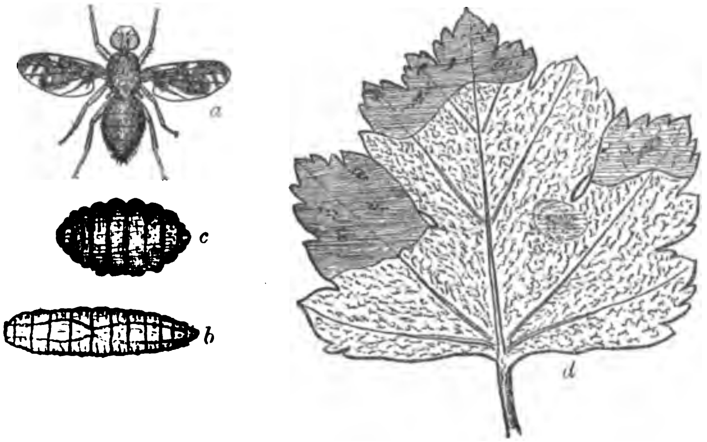

Fig. 4.—(*a*) Celery-Fly (*Acidia heraclei*). (*b*) puparium; (*c*) maggot: all × 3; (*d*) blistered leaf: natural size.

Enchytræid Worms.

Enchytræus parvulus, Friend.

In my paper on Insects observed during 1902 (3, 1902, pp. 202–3), reference was made to the damage done to Celery and other garden plants by these small, white Annelids. In February, 1904, complaint was received of serious injury by them to Celery in County Sligo, and the application of a heavy dressing of salt, found effectual in Dublin, was recommended.

Specimens of these worms were received in November, 1904, sent from Belfast by my friend, Mr. W. H. Patterson, who had found them at the roots of grass on a lawn that turned brown in circular patches. More abundant, however—probably the main cause of the damage—were small, white Springtails.

Springtails.

Lipura ambulans (Linn.).

As just mentioned, these little insects, described and figured in my last paper (3, 1903, pp. 251–3, fig. 3), were exceedingly numerous in a Belfast garden, doing much harm to Cabbage and other vegetable roots. Mr. Patterson kindly informs me that he has succeeded in clearing the soil of them to a great extent by applying gas-lime to the amount of about six tons to the acre.

Similar complaints reached me from Mr. J. W. Warburton, of Rostrevor. He wrote in May, forwarding specimens of *Lipura ambulans*, and stating that he found the insects most destructive to bulbs, Cabbage, Cauliflower, and other vegetables, and various flower roots. Applications of lime with soot were found to keep them in check, but only partially. Mr. Warburton tells me that he finds the Springtails constantly attacking perfectly sound bulbs and roots, thus affording further evidence of the destructive *rôle* now played by these small, frail insects, whose power for mischief depends on their rate of multiplication, and their consequently large numbers.

Root Mites.

Rhizoglyphus echinopus (Furn. & Rob.).

Reference was made to these destructive mites in my paper of last year (3, 1903, pp. 258–260, fig. 6). Specimens of Daffodil bulbs destroyed by them were received in August from Mr. J. Bell, of Tibradden, Co. Dublin.

ORCHARD INSECTS.

The Vapourer Moth.

Orgyia antiqua (Linn.).

Caterpillars of this familiar moth were received in August from County Leitrim, where they had done some damage to the foliage of young Apple-trees which had been planted in the spring after importation from France. This moth has a wingless female, laying her eggs in the autumn on the cocoon from which she has emerged, and they remain unhatched till the following spring. We must conclude, therefore, either that eggs of the insect were imported with the trees, or that the caterpillars migrated to the trees from some neighbouring feeding-ground. They devour greedily plants of many different kinds, notably Rosaceæ, and are very active in their habits.

The Small Ermine Moth.

Hyponomeuta padellus (Fab.).

Damage to the foliage of Apple-trees, at Glasnevin, by the web-spinning caterpillars of this well-known moth was reported by Mr. F. W. Moore in June.

The Pear Midge.

Diplosis pyrivora, Riley.

In June I received, from Dr. G. H. Pethybridge, young Pears infested with the maggots of this destructive midge. They had been obtained by Mr. Magill, Horticultural Instructor, from an orchard in County Tyrone, where the trees, about fifteen years old, are said to be much too thickly planted. Specimens were also found numerously in an orchard close to Dublin. So far as I know this midge has not been previously recorded in Ireland, and it deserves, therefore, some detailed notice, as it is of importance that owners of orchards should be on their guard against it. The life-history has been fully described in this country by Meade (7), and Ormerod (9, 1896, 1898), and in America by Smith (12).

The insect belongs to the family of Cecidomyiidæ or Gall-midges, which are recognisable by their minute size, elongate feelers, simple wing-neuration, and the elongation of the terminal segments of the female's hind-body to form a tubular ovipositor. According to Meade's description, *Diplosis pyrivora* is about 2 mm. ($\frac{1}{12}$ inch) in length, with the head and fore-body black, with greyish reflections, and the hind-body dark brown with whitish hairs. There are patches of yellow hairs on the head and above the wing-bases, and the feelers are yellowish-brown (fig. 5, I). The female midges appear in spring when the pears are in blossom, and lay their eggs in clusters of six to eight, or more, in the blossoms. Smith states that the female inserts her ovipositor into the bud wherever she can do so most easily, and that the eggs, covered by a membranous adhesive material, may be found in any part of the blossom. From these eggs are hatched out the small, yellow or orange maggots which eat their way into the young, developing fruit. The maggot of a Gall-midge may be recognised by the peculiar, hard, chitinous, "anchor-process," or "breast-bone," situated on the ventral surface between the prothorax and the hinder segment of the head, which in these maggots is distinct from the very small head-capsule (fig. 5, 2). The anchor-process of *D. pyrivora* is very elongate and slender, broadened suddenly at its distal (forward) end (fig. 5, 5). As forty or fifty maggots may be found in a single pear, it is likely that several midges lay their eggs in a single blossom. The maggots feed on the tissue of the young fruit around the seed capsules, and the result of their presence is that when the pears are from ⅓ inch to 1 inch long they stop growing. By the middle of June the maggots have attained their full length of 4 mm. (⅙ inch); the fruits they inhabit can usually be easily recognised by their distorted, stunted appearance (fig. 5, 4), the inside becoming black and decayed. The infested pears crack open, and often fall from the tree. In any case the

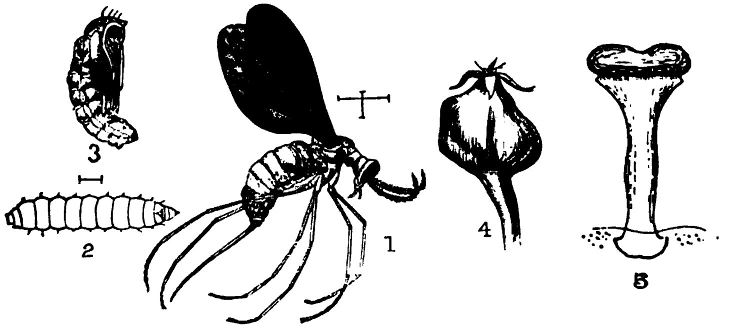

Fig. 5.—1. Female Pear-Midge (*Diplosis pyrivora*). 2. Maggot. 3. Pupa (magnified). 4. Stunted Pear (natural size). From Ormerod, after Riley. 5. Anchor-process: × 80.

maggots, which are very active, and able to leap, by means of the successive folding and straightening of their bodies, wriggle out and alight on the ground. Then they bury themselves an inch or two deep in the soil, and remain resting until autumn, after which they surround themselves with their silken cocoons with grains of sand attached. In spring the larval skin is cast, and the pupa (fig. 5, 3) revealed, whence the midge soon emerges to lay her eggs on the blossoms.

As Smith points out, the concealed feeding habit of the maggots within the pears renders any kind of spraying useless. But the fact that there is only one life-cycle in the year, and that from midsummer until spring, all the insects are buried an inch or so in the soil beneath the trees, either in the larval or pupal stage, affords a sure means for preventing the recurrence of the attack. Smith has shown that a heavy top-dressing of kainit, applied in late summer or autumn, acts most effectually in killing the maggots. Needless to say, infested pears should be collected and rigorously destroyed.

The Apple-Plant Louse.

Aphis pomi, De Greer.

Complaints of damage to old Apple-trees by this well-known pest were received in July from County Tyrone. Its life-history has lately been worked out in detail by Smith (13), who lays stress on the fact that the young Aphids, first appearing in spring, are hatched from the winter eggs within a fortnight of the first appearance of the foliage; spraying with paraffin or tobacco emulsion at this period is therefore of especial importance. Theobald, however, who has recently shown us how to distinguish this species from other Aphids of the Apple (16, pp. 22–33), insists that autumnal spraying, so as to kill the sexual females before they can lay their eggs, is of much greater value.

The Black-Currant Mite.

Eriophyes ribis (Westwood).

Complaints of damage due to this mite, described and figured in my last paper (3, 1903, pp. 260–262, fig. 7), continue to be received from various parts of the country. The Rev. C. H. Waddell informed me, for example, that out of a plot of twenty bushes in a County Down garden, half had been destroyed.

FOREST INSECTS.

The Green Bell-moth.

Tortrix viridana, Linn.

At midsummer, I learned from Mr. Thos. Acton, of Kilmacurragh, Rathdrum, that the oak-woods in the Vale of Avoca, County Wicklow, were suffering severely from the ravages of the well-known green leaf-rolling caterpillars of this moth. From a few branches kindly sent by Mr. Acton, I reared over a hundred moths. The dried-up appearance of the foliage during the height of this attack made the woods look as if scorched by fire.

OSIER INSECTS.

Willow-bud Gall-midge.

Rhabdophaga heterobia (Loew).

In the winter of 1903–4, I received information from Mr. R. H. Prior-Wandesforde, of Castlecomer House, County Kilkenny, of serious injury caused to Osiers by the maggots of a Gall-midge; and during the summer he kindly sent me fresh specimens of the galls, with the maggots living socially within them. The Abbé Kieffer has kindly identified the species as *Rhabdophaga heterobia*, Loew, a species well known on various species of *Salix*, but not, I believe, hitherto recognised as injurious to Osiers.

The midge is a minute, hairy, black insect (fig. 6, *a*). The ovipositor of the female is shorter than in *Diplosis pyrivora*, and the wings show a very markedly obtuse angle at the forking of the third nervure.

The maggots live, six or eight together, in the buds of the Osiers. Their presence there causes the leaves to become stunted and twisted, and covered with a dense, white, woolly growth, which serves as a shelter for the insects (Plate XXVI., B). The gall has been figured by Kieffer (5). The buds being thus arrested in their growth, no new shoots are formed, and the damage done to Osiers grown for industrial purposes becomes serious. Mr. Prior-Wandesforde informs me that the insects "confined their attack almost entirely to the dark-skinned variety of Osier which we call the 'Norfolk,' and which is about the best we have for yielding light, clean, hard rods for the better class of basket-work; all these Osiers were destroyed, but the greener varieties of Osier, more suitable for growing big, heavy rods and sticks, such as

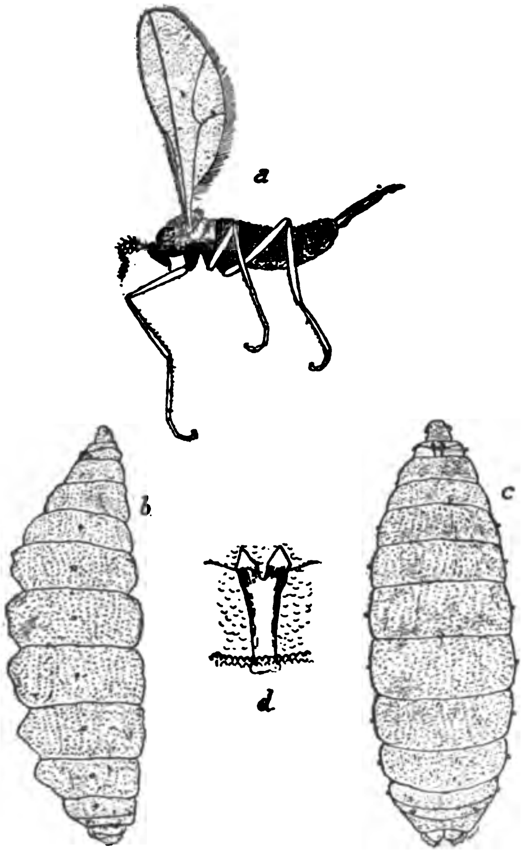

Fig. 6.—Osier Gall-Midge (*Rhabdophaga heterobia*, Loew). (*a*) Female, side view ; (*b*) Maggot, side view ; (*c*) Maggot, ventral view : × 50 ; (*d*) Anchor-process : × 150.

'Spaniards,' 'Black-tops,' 'Black-mauls,' were very little attacked, and in some cases of 'Spaniards,' where there was an odd plant put by mistake among the 'Norfolks,' the 'Spaniard' was untouched, and the 'Norfolks' covered with grubs."

The grub is about 1 mm. long, thicker in proportion than the maggot of *Diplosis pyrivora*, and of a bright orange colour; the skin is covered with numerous small, blunt denticles. The anchor-process (fig. 6, *d*) is comparatively short and deeply bifid distally. The process, as figured by Rübsaamen (11, plate xviii., fig. 10), has a broader base than in my specimens; but its general form agrees with what I have observed, and there is doubtless a considerable amount of variation in such matters of detail within specific limits. These grubs do not go underground, but pupate within the galls. My friend Dr. R. Stewart Macdougall has confirmed this by keeping the galls over the winter, and rearing midges in the succeeding spring. From this it appears that cutting and burning the infested shoots should prevent a recurrence of the attack. Mr. Prior-Wandesforde tells me, however, that the Osiers were injured badly both in 1903 and 1904, though the galled shoots had been burned in 1902 and 1903. Possibly the parents of the new generation made their way to the Osier-beds from neighbouring Willow-trees.

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EXPLANATION OF PLATE XXIII.

EXPLANATION OF PLATE XXIII.

PLATE XXIII.

Fig.

1. Portion of Mangold leaf, showing cluster of eggs of *Pegomyia betæ*, with burrows formed by maggots: × 7.

2. Two eggs of *P. betæ*, one showing external sculpture, the other the maggot surrounded by embryonic membrane within: × 35.

3. Newly hatched maggot: × 12; 3 *a*, mouth hooks: × 75; 3 *b*, tail end of maggot: × 30; 3 *c*, a tail spiracle: × 75.

4. Maggot, second stage: × 12; 3 *a*, mouth hooks: × 54; 3 *b*, tail end of maggot: × 30; 3 *c*, a tail spiracle: × 75.

5. Maggot, later stage: × 7; 5 *a*, mouth hooks: × 35; 5 *b*, prothoracic spiracle: × 130.

6. Maggot, full-grown: × 7; 6 *a*, mouth hooks: × 35; 6 *b*, prothoracic spiracle: × 130; 6 *c*, tail end of maggot: × 14; 6 *d*, a tail spiracle: × 45.

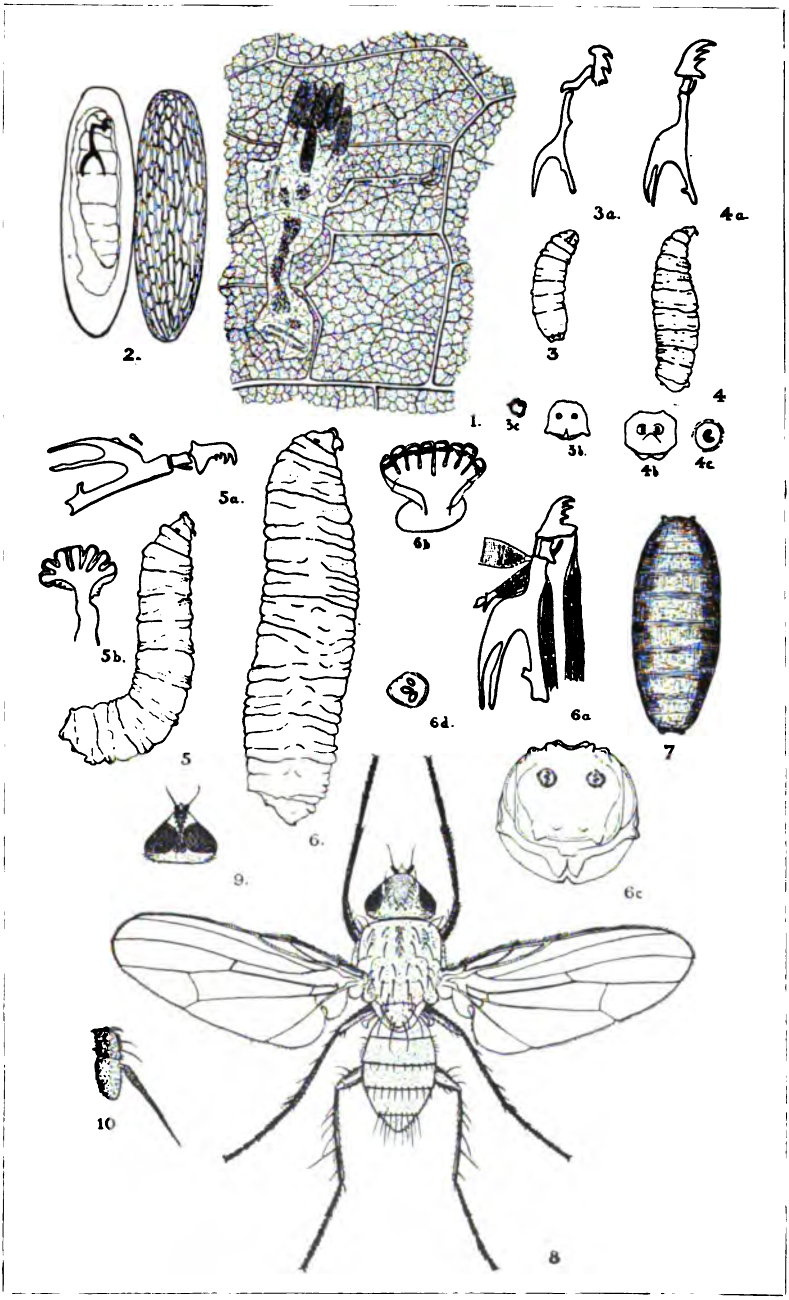
7. Puparium: × 7.

8. Female Mangold fly (*Pegomyia betæ*): × 7.

9. Head of Male Fly: × 7.

10. Feeler of Male Fly: × 30.

PLATE XXIII.



G. H. C., del.
McFarlane & Erskine.

EXPLANATION OF PLATE XXIV.

PLATE XXIV.

Mangold Plants, with outer leaves mined by maggots of *Pegomyia betæ.*

[From a photograph by W. A. Murphy.]

PLATE XXIV.

EXPLANATION OF PLATE XXV.

PLATE XXV.

Fig.

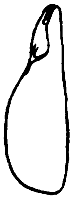
1. Oribatid Mite (*Lohmannia insignis*, Berlese), dorsal view; legs removed: × 45.

2. The same, ventral view: × 45.

3. The same, chelicera: × 120.

4. The same, left pseudostigmatic organ: × 120.

5. The same, terminal segments of forefoot: × 120.



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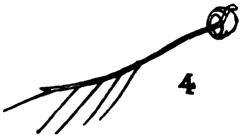

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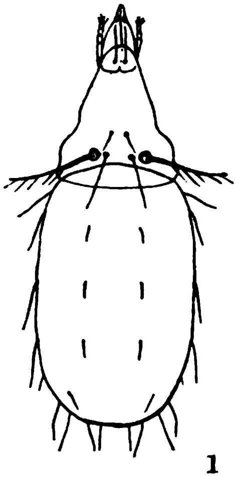

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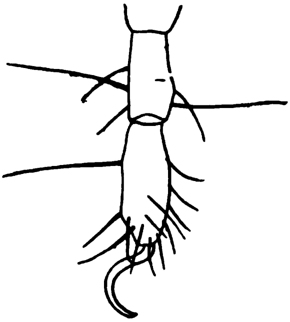

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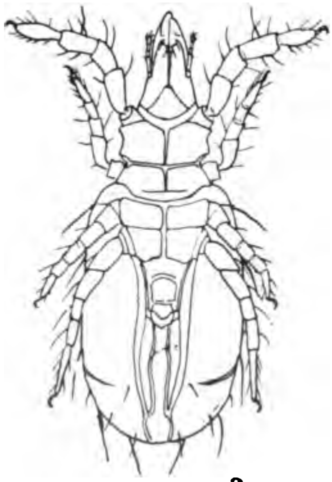

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G. H. C., del.

EXPLANATION OF PLATE XXVI.

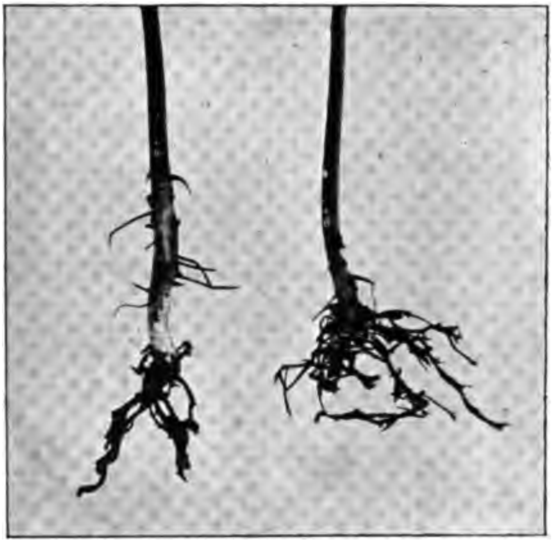
EXPLANATION OF PLATE XXVI.

PLATE XXVI.

A. Roots with surface gnawed by Springtails (*Lipura*) and Oribatid mites (*Lohmannia insignis*).

B. Buds of Osier galled by Maggots of *Rhabdophaga heterobia* (Loew).

[From photographs by T. Price.]



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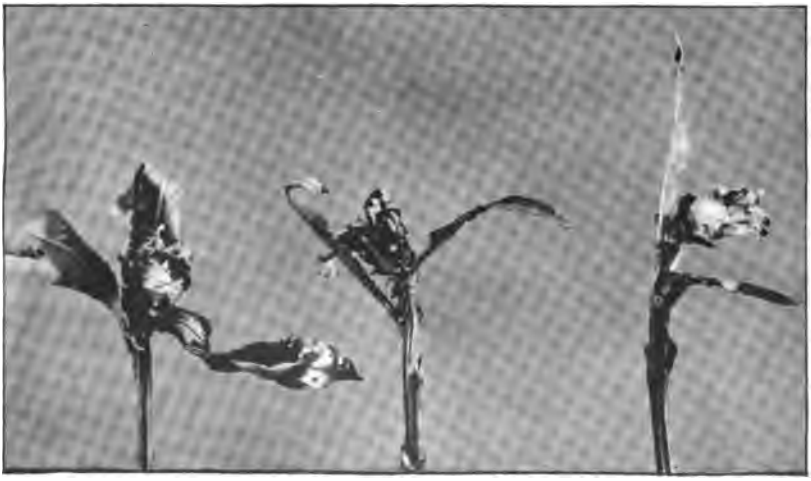

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XV.

THE CAUSES OF "BLOWING" IN TINS OF CONDENSED MILK.

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Introductory.

One of the difficulties against which manufacturers of condensed milk have to contend is the fermentation of the milk after enclosure in tins, gas being produced which causes the ends of the tins to become bulged outwards, the tins then being said to be *blown*. Fermentation or decomposition of tinned articles of food may result in the most serious consequences to the consumers of such articles, many cases of poisoning having occurred in this way. The products arising from such decomposition will depend partly on the nature of the foodstuff concerned, whether meat, fish, &c., and also on the nature of the organisms producing the fermentation: and it does not necessarily follow that because blown tins of meat or fish are likely to be dangerous to health, similar tins of milk or vegetables will be equally dangerous; as a matter of fact, the milk from the blown tins with which I have had to deal would probably be comparatively harmless for adult human consumption, and at any rate it has been fed to pigs and cattle without ill effect.

The law, however, makes no such fine distinctions between the different foodstuffs and their fermentations, but visits with very heavy penalties any person offering or exposing for sale foodstuffs of any kind in tins which are visibly "blown." The manufacturer of condensed milk, therefore, must endeavour to prepare his product so that it will not subsequently ferment. In this he is, perhaps, somewhat at a disadvantage as compared with the manufacturer of other tinned foods. In the latter case it is, as a rule, practicable to actually *sterilise* the contents of the tins by heat, whereas in the case of condensed milk the product becomes browned and deteriorated in quality if too much or too long-continued heat be applied to it during any stage of its manufacture.

There remains of course the alternative of using a "preservative";[1] but first-class manufacturers rightly hesitate before adding such undesirable substances to their milk, relying rather on absolute cleanliness in the process of manufacture to ensure a good, keeping product. And where a strict control as to cleanliness can be kept, not only over the milk during manufacture, but also—what is perhaps more important still—over the sources of supply of the milk, there is no difficulty in preparing such a product.

In the case with which I am about to deal, an Irish milk-condensing company had been troubled with the blowing of their tins, and I was asked by their manager to ascertain the cause, and, if possible, to suggest a remedy. As regards the occurrence of blown tins, the manager writes:—"We do not get blown tins in each batch; like any other disease, it is very erratic. Sometimes for months we won't have a single blown tin; then, without any apparent change in mode of manufacture, we get a lot, or, perhaps, a batch made on some particular day will go wrong, and every other batch will be right. . . ."

EXPERIMENTAL INVESTIGATION OF BLOWN TINS.

In the factory blowing usually shows itself about six weeks after tinning has taken place. I was supplied with a number of such blown tins from different batches with which to carry out my investigations. The milk used is separated milk, and nothing whatever is added to it in the process of manufacture except cane-sugar.

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[1] The word "preservative" is used here to signify a chemical antiseptic added in small quantities, and does not apply to the cane-sugar added to the milk to preserve it.

A blown tin from batch No. 3525, manufactured on September 22nd, was opened on January 19th. On opening the tin the milk was squirted to some considerable distance, owing to the pressure of the accumulated gas. In colour the milk differed but slightly, if at all, from that of sound, unblown tins; there was no unpleasant taste, bitter or otherwise, but a very faint alcoholic smell was discernible. On pouring out the milk in a thin stream from the tin, a number of clots were observed. These clots were fairly firm in texture, but on shaking well in water they gradually dissolved and gave a milky solution. They are not present in the milk of sound tins. Examination of them under the microscope revealed the presence of micro-organisms in abundance. Most of them seemed dead, as if killed by heat; but many apparently alive were also observed. Numbers of apparently dead and disorganized cells were also observed in the general class of unclotted milk.

Preliminary cultures made from the unclotted milk showed that, although not sterile, it was, on the whole, very free from living micro-organisms; no prevailing form of any kind could be found in such quantity as to suggest that it might have been the cause of the blowing. Attention was therefore next directed to the clots; and the following four experiments were carried out with them:—

(1) A large clot was removed and thoroughly washed in three successive changes of sterile water. The size was thereby much reduced; the outer portions of the clot being washed away, leaving a rather firmer central nucleus. This clot was then placed in a small flask of Pasteur's solution, shaken well so that it dissolved, and placed in a 20° C. incubator. During the first three days growth was slow; but on the third day a number of minute white dots became visible to the naked eye on the bottom of the flask, which grew larger daily, and which by the fifth day had become fairly large, flocculent masses floating in the solution. At the same time gas-bubbles were observed rising in the solution, which was thus in a state of fermentation. The flask was allowed to stand for twenty-three days longer, during which time the fermentation came to a stand-still, a white sediment was deposited on the bottom of the flask, and a thin film formed on the surface of the liquid. Microscopic examination of the flocculent masses showed the presence

of actively budding yeasts in them; and yeasts, both spherical and oval in form, were found in the film, and in the deposit.

On thoroughly incorporating a portion of one of the flocculent masses with ordinary, melted, nutritive gelatine, and pouring several plates, the following growths were obtained:—

(*a*) One yellowish-green, slowly liquefying colony, consisting of cocci.

(*b*) One large white colony with a wavy margin, consisting also of cocci.

(*c*) About a dozen colonies of a smallish spherical yeast.

(*d*) A preponderatingly large number of exceedingly minute colonies of a small oval yeast.

The minute size of the colonies of this last-named preponderating form was due to the lack of sugar in the gelatine, as was proved by their rapid increase in size in the neighbourhood of small pieces of glucose subsequently placed on the surface of the jelly and diffusing into it.

Sub-cultures of the colonies *c* and *d* were made in cane-sugar gelatine and in wort gelatine, the colonies being found to be pure, and the resulting colonies in these sugar-containing media were much larger than the original ones in ordinary gelatine. Colonies *a* and *b* did not receive any further attention.

The invariable presence of clots in the blown tins, and the isolation of this small yeast in large numbers from the clots, led me at once to suspect this organism as the cause of the trouble. Since, however, there were other organisms present in the clot, and its presence in large numbers might have been due to the selective action of the Pasteur's solution (the other forms, perhaps, not growing so readily in this as the most prevalent one did), it was necessary to plate out directly from the clot.

(2) A second clot was washed in six successive changes of sterile water, introduced into a tube of melted glucose gelatine (2 per cent.), and by means of a sterile rod pulverised as thoroughly as possible. After thorough shaking, a number (five) of other glucose gelatine tubes were inoculated with diminishing quantities from this first tube, and plates poured. After remaining for a week at room-temperature, the plates gave the following results:—

Plate 1.—Inoculation was too strong, plates being thickly covered with myriads of minute colonies. An individual of *Rhizopus nigricans* had also grown all over the plate, which was, therefore, not further utilised.

Plate 2.—A very large number of small colonies, yellowish-white in colour, similar to one another in size and shape, and proving by microscopic examination to consist of a small, oval yeast. In addition to these, about two dozen larger colonies, easily distinguished from the others by the naked eye, proving on microscopic examination to consist of spherical yeast-cells. These two forms corresponded to those of *d* and *c* respectively mentioned above.

Plate 3.—Similar to plate 2 ; but the numbers of both kinds of colonies were reduced.

Plate 4.—Numerous colonies of the small, oval yeast, none of the spherical one. In addition, there were three much larger colonies, which consisted of rod-shaped bacteria.

Plate 5.—A pure culture, consisting of a number of colonies of the small, oval yeast only.

(3) A third clot, washed in tap-water, was placed in sterile beer wort, and allowed to stand at 20° C. Owing to an oversight, the flask was not examined until an interval of nearly four weeks had elapsed. Microscopic examination, however, showed the presence of the oval yeast as well as the spherical one, together with a large number of various bacteria, some of which had been doubtless introduced during the washing in tap-water.

(4) Some of the clots were placed, immediately the tin was opened, in a sterile Petri dish, and allowed to remain there for four weeks, during which time they dried considerably, and became waxy in consistency. At the end of this time one of these clots, after washing in sterile water, as before, was pulverised, and well shaken in cane-sugar broth (2 per cent.), and allowed to stand over night at 20° C. On the next day inoculations were made from this into cane-sugar gelatine, and plates poured. The resulting growths were quite similar to those previously obtained, and the colonies of the small, oval yeast were again the predominant ones on all the plates.

These four experiments, therefore, all go to prove that the flora of the clots consisted of (*a*) predominantly large numbers of a small, oval yeast; (*b*) a small number of a spherical yeast; (*c*) a very few bacteria. The predominant yeast (or better, perhaps, *torula*), isolated in these experiments, is oval in shape, with a maximum length of 3·6 μ., and a breadth of about one quarter of this. Most of the cells are, however, smaller than this. Multiplication is by budding in the usual manner. Spores were not observed in any of the cultures; but no special attempt was made to obtain them, and in no case was any mycelium produced. The whitish-yellow colonies, which grow on gelatine media containing glucose or cane-sugar, appear equally vigorous, whether on the surface or submerged. When submerged the colonies are spherical, with more or less tuberculated surfaces. On ordinary agar and gelatine media containing no sugar, the yeast grows very badly; in fact, on agar no growth at all was observed. The same absence of growth was noted in broth containing 2 per cent. of lactose. On the other hand, in media containing glucose or cane-sugar, growth was very active, glucose broth (2 per cent.) being fermented with vigour, and cane-sugar broth (2 per cent.) only a little less energetically. Abundance of gas was also produced in a cane-sugar gelatine shake-culture. In ordinary sterilised, separated milk the organism did not seem to thrive at all well, and no gas whatever was developed.

Having proved the presence of this small, oval yeast in large numbers in the clots of the blown milk, it was now necessary to find out whether condensed milk could be blown by pure cultures of this organism, and the following four experiments were carried out:—

(1) A mixture of condensed milk (from a sound, unblown tin of another batch), diluted with three times its volume of water, was sterilised and inoculated with the organism. Melted, sterile vaseline was poured on the surface of the milk after inoculation, and allowed to cool and solidify. Tubes were kept at 20° C. and 37° C.

Result.—Strong production of gas in all tubes at both temperatures in two days.

(2) Tubes of undiluted condensed milk from the same tin as in (1) were sterilised, inoculated with the yeast, vaselined, and placed at 37° C.

Result.—Gas was formed in two out of three of these tubes in thirteen and twenty-five days respectively. In the third tube no gas was produced. The condensed milk was rendered almost solid by the process of sterilisation, owing to loss of more water. Yet gas was produced, slowly, it is true, in two cases out of three; the absence of gas in the third tube is probably to be accounted for by faulty inoculation. In the two tubes in which gas was formed the presence of the yeast in abundance was found both by microscopic observation and by plating out.

(3) Tubes of condensed milk from the same tin as in (1) and (2) (without previous sterilisation) were inoculated with the yeast, vaselined, and placed along with control tubes of the same milk and vaseline, not inoculated, at 20° and at 37° C.

Result.—At the former temperature all the tubes showed gas-production in twenty-four days, at the latter temperature five days earlier. In the control tubes no gas whatever was developed.

(4) Two tins of sound, unblown condensed milk were opened, inoculated with the yeast, re-sealed with solder, and placed along with a control tin of the same milk at 37° C.

Result.—In inoculating the first tin it was found that it was already so full that it was difficult to re-seal; the hot soldering iron causing the contents to expand and exude from the tin, thus preventing the proper adhesion of the solder. This imperfectly sealed tin showed signs of gas-production in a very few days, and the frothing contents escaped from the imperfectly closed inoculating hole in the lid. From the second tin a portion of the contents was withdrawn by means of a sterile pipette before making the inoculation. By this means it was possible to completely close the tin again with solder. After twenty-three days (about one-half of the time taken in the factory at ordinary temperatures) this tin presented the typical appearances of a blown tin, with both its ends bulging outwards. On opening these two inoculated tins, the characteristic clots were found in them, some of them very large, and adhering to the sides and bottoms of the tins. Gas-bubbles were observed in the still liquid part of the milk, which was considerably browned (probably owing to its having been kept at blood-heat for so many days), and the contents of the tins had a very distinct alcoholic smell.

Plate cultures from these tins proved the presence of the yeast in overwhelmingly predominant numbers. There was no sign of blowing in the control tin. Its contents were somewhat browned; there were no clots, and no alcoholic smell.

These experiments prove conclusively that this organism can produce blowing in condensed milk; and seeing that it was present in large numbers in the original tin, there can be no doubt but that the blowing of the tins in batch 3525 was due chiefly to this yeast.

Turning now to the second yeast—the spherical one, about 5·5 μ. in diameter—which was also isolated from the clots, but which was present in far smaller numbers. It grows fairly well on ordinary agar and gelatine when no sugar is present. It does not ferment lactose. Its colonies on cane-sugar gelatine (2 per cent.) are larger than those of the above-mentioned yeast, and it appears to thrive better on the surface than when submerged. It was inoculated from a pure culture into sterilised condensed milk, as in experiment (2), above, and two tubes out of the three inoculated showed gas-production after being incubated for twenty days at 37° C. It was further inoculated into a tin of sound condensed milk, as in experiment (4), above, and it caused the tin to blow, whereas a control tin incubated in the same manner did not do so. Hence this organism also, although present in smaller numbers, was partly responsible for the blowing of the tins of batch 3525.

It was next desirable to ascertain, if possible, from what source these organisms came into the milk. It was, of course, not possible to examine the original milk-supply used for this batch; but it was quite possible that they might have been introduced with the cane-sugar.

INVESTIGATION OF CANE-SUGAR.

I was fortunate in being able to obtain a sample (about 50 g.) of the actual sugar which was used in the manufacture of the tins of milk of batch 3525. It is known that torula forms are frequent in sugar-factories; and, according to Jorgensen,[1] they are often found in considerable amounts in the finished product.

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[1] A. Jorgensen, Die Mikroorganismen der Gärungsindustrie. 4te Auflage. Berlin, 1898, p. 248.

Hence I carried out a very careful series of experiments to ascertain if the yeasts isolated from the blown tins were contained in this sugar. These experiments were repeated three times with entirely negative results; no yeasts of any kind were to be found in it. On the other hand, a number of moulds and bacteria were present, especially rapidly gelatine-liquefying forms of the latter; but amongst these there were no gas-formers either in glucose or lactose media. The sample of sugar was, it is true, relatively small, and, had a larger amount been available, possibly yeasts might have been discovered in it. As far as batch 3525 therefore was concerned, it was impossible to discover how or when the milk had become contaminated by the yeasts.

I was also supplied with a second sample of sugar, but with no information as to what batch of milk it was used in condensing, or as to whether blowing took place. Nevertheless, several experiments were carried out with it, the more important of which may be mentioned here. When about 25 grammes of this sugar were put into 250 c.c. of ordinary broth, and kept at 37° C., a vigorous fermentation was set up in a short time, and after standing for about three weeks, a surface-film containing a spherical yeast was developed.

This yeast was isolated in pure culture, inoculated into non-sterilised condensed milk from a sound tin, vaselined, and put together with a control, at 37° C. Neither in the inoculated tube, however, nor in the control was gas developed. This experiment was repeated, with a second negative result. Hence this yeast, though by microscopic observation very similar to the one obtained in small numbers from the clot of 3525, cannot be identical with it, and would, as far as can be seen, not produce blowing in tins of condensed milk.

This sample of sugar proved rich in bacteria. A rapidly gelatine-liquefying form was very common, as was also another growing in the form of glassy-looking, viscous, or slimy colonies rising above the surface of the gelatine.[1] In addition to these two and a few others, a very strong, gas-forming, rod-shaped form was found in some quantity, and isolated. Some attention was paid to this form, as it was thought that possibly if frequent at any time in condensed milk, blowing might be the result. The organism did not seem particularly partial to any one form of medium. It grew fairly well in ordinary agar, and in ordinary gelatine, but better if these media were supplied with 2 per cent. of lactose, glucose, or cane-sugar. Gas was produced from these three sugars by it, lactose being more vigorously attacked than the other two. Growth was good in ordinary sterile milk, a firm curd being formed, and plenty of gas. The organism, however, even if present in a living state in condensed milk, would not be able to blow the milk; it is rather a form which, although isolated from crystallised sugar, is inhibited in its growth by increasing amounts of cane-sugar, as the following results will show:—

---

[1] A viscous form quite similar to this was isolated from the still liquid milk (not a clot) of a blown tin of batch 3516. This suggests that organisms may be introduced with the sugar, and may survive the subsequent high temperature which occurs during manufacture.

(*a*) In 2 per cent. cane-sugar broth gas was vigorously produced in two days.

(*b*) In sound condensed milk with three times its volume of water, sterilised, gas was also produced vigorously in two days.

(*c*) In sound condensed milk (not sterilised), with a control tube, no signs of gas after four weeks.

(*d*) In sterilised condensed milk no gas after remaining for nearly six months at 37° C.

The influence of cane-sugar in diminishing the growth of this organism was also confirmed by growing it in gelatine with the addition of 2 per cent. and 20 per cent. of cane-sugar, there being markedly less growth in the latter case.

So far as each of these sugars is concerned, therefore, an organism capable of blowing condensed milk was not discovered. This result confirms the opinion of the manager of the company, which was that the sugar could not contain the organism causing the blowing. The supply of milk used for condensing is obtained from two main sources; and it was noted that when milk from one of the sources was condensed by itself, blowing never occurred, whereas it did occur when the milk from the two sources was mixed. The contamination therefore must have been present in the milk from the other source of supply.

OTHER BLOWN TINS.

Less detailed investigations were made on blown tins from three other batches of condensed milk which may be briefly summarised.

Batch "*C.*"—From the clots a yeast, similar macroscopically and microscopically to the small, oval yeast of 3525, was isolated in preponderatingly large numbers. Portions of a *clot* introduced into sound, non-sterilised condensed milk, and vaselined, produced blowing in two days at 37° C., and in three days at 20° C., the control tubes in neither of the two cases showing any signs of gas. Inoculations with a pure culture were not made in this case.

Batch 3516.—From the clots a small, oval yeast was isolated similar in the size of its cells to that found in 3525, but differing in the size and shape of its colonies. From the still liquid milk of this tin another form was obtained. These two forms, however, when inoculated into sound tins, did not produce blowing; but the experiment was only tried once.

Batch 3518.—Two forms were isolated here, one large one from the clots, and a second smaller spherical one, very similar to, if not identical with, the spherical form of the clots in 3525. The former of these when inoculated into a tin of sound condensed milk did not produce blowing; but the second one caused very strong blowing of the tin in twenty-seven days at 37° C., control tins remaining unaltered during the same time.

There can be no doubt therefore that the blowing of condensed milk in tins is due to the fermentation of the cane-sugar added during manufacture, by yeasts, and it would appear that the yeasts concerned are not added along with the sugar.

PREVENTIVE MEASURES.

In order to suggest remedies for the trouble, it would be necessary to ascertain at what stage the yeasts get into the milk. This would of course be best done by continuous observations made on the spot by one who could carry on systematic experiments on the milk at all stages, from its milking to its final enclosing in tins. A few such investigations were made by me from time to time, which will be mentioned presently; before doing so it will be well to give a brief account of the process of manufacture. The separated milk used is obtained in bulk from two independent sources in towns about fifty miles apart. In the first of these the milk, immediately after separation in an adjoining creamery, is heated to 80° C., and then flows into the condensing factory, where it is stored for as short a time as possible in a tank. It is then raised to the boiling point in another vessel, drawn up into a vacuum pan, and evaporated down in this at a temperature of 40° C. The then condensed milk flows over a refrigerator, which cools it down to about 9° C., is filled into large cans, and despatched to the second town, where it arrives on the following day.

At the second town this (non-sugared) condensed milk from the auxiliary factory is mixed with freshly separated boiling milk from the second source of supply, and the mixture brought to the boiling point. Crystallised cane-sugar is then added at the rate of 1·4 lb. per gallon, which reduces the temperature somewhat, and during solution the temperature is once more raised to the boiling point. The sweetened milk now passes into a reservoir, and after a short interval is drawn into a vacuum pan, where it is concentrated at a temperature of 40° C. After concentration the milk is cooled and subsequently filled into the tins.

It will be seen that at no stage during its manufacture is the milk kept *for any considerable length of time* at a high temperature, nor is it possible to do this without injuring the market value of the finished product, owing to the discolouration produced by the effect of heat on the albuminoids[1] of the milk. It is, therefore, out of the question to suggest that an endeavour should be made to secure more thorough sterilisation by heat during any part of the process. It will also be noted that the temperature in the vacuum pans is one very favourable to incubation.

The conditions as to cleanliness in both branches of the factory seem to leave little, if anything, to be desired; indeed, special vigilance is exercised, and no solution of the difficulty can be expected from changes in this respect.

To get to the bottom of the difficulty it is necessary to ensure that the milk from the sources of supply in the first place shall be absolutely clean and free from suspicion. This is, however, in practice one of the most difficult things to do.

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[1] O. Jensen, Centralblatt für Bakteriologie, Abth. II., Bd. 13, 1904, p. 431.

As mentioned above, the trouble in this case was traced to the milk of the auxiliary factory. The condensed (unsweetened) milk produced at this auxiliary factory was examined on four occasions and found to be swarming with micro-organisms. Gas was produced in large quantities, so much so that some of the tins in which the samples of milk were supplied actually burst open with some violence in a few days at room-temperature. *Oidium lactis* was found in plenty, as well as numerous bacteria, both liquefiers and gas-formers. The blowing of these tins of unsweetened milk is, undoubtedly, due to the fermentation of the lactose by these gas-forming bacteria, and is therefore of a different nature from the blowing of the sweetened milk. If any of these bacteria survived the subsequent high temperature involved, they would be inhibited in their action by the concentration of the cane-sugar (see p. 315). Living yeast-cells, both spherical and oval, were observed in this milk, and it was an easy matter to accelerate their growth and increase their number by the addition of glucose or cane-sugar. These yeasts apparently survive the subsequent temperatures, and produce the trouble when the cane-sugar is added.

The concentration of the cane-sugar seems to have no effect in inhibiting the fermentation set up by the particular yeasts concerned in blowing the tins. The condensed milk in the tins consists of water 27·2 per cent., solids, not fat, 28·8 per cent., and added sugar 44 per cent. The milk is saturated with sugar, and undissolved crystals of it can be seen in the milk under the microscope. The yeasts causing blowing, therefore, are able to ferment such a saturated solution, and an increase in the amount of sugar used in condensing the milk would be of no avail. In this respect these wild yeasts differ from the larger, cultivated races. Wiesner[1] found that with baker's yeast (Presshefe) fermentation began to be adversely influenced at concentrations between 25 and 35 per cent., and that at a concentration of 75 per cent., and in saturated solutions of cane-sugar, fermentation did not take place at all.

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[1] Wiesner, Sitzber. d. Wiener. Akad. Abth. II., 1869, Bd. 59.

Lastly, the fresh milk as supplied by two of the clients to the creamery from which the above auxiliary factory obtained its supply of separated milk was examined. Both samples proved to be exceedingly dirty, becoming mouldy on the surface in a very short time, and being rich in other micro-organisms, *including yeasts.* The trouble was, therefore, traced back to the original milk-supply, and measures were taken by the manager to improve this. By testing the suppliers' milk not only for acidity, but also for micro-organisms, more especially those producing gas, he was able to considerably improve the quality of his supply. During one month as many as fifteen hundred gallons of "dirty" milk were rejected, and the manager writes, "There is no doubt whatever that the concentrated article is much better now than it was a few months ago."

SUMMARY.

1. In the manufacture of condensed milk, "blown" tins occur in a sporadic manner among the batches, such blown tins usually being evident about six weeks after their manufacture.

2. The milk in such tins does not differ much in appearance, taste, &c., from that of sound tins; but small clots are found in the blown tins which are absent from sound tins.

3. In these clots—and to a smaller extent in the non-clotted milk—small yeasts or torulæ are present in large numbers.

4. These yeasts were proved to be capable of producing the blowing of the milk in the tins.

5. Unlike the other micro-organisms found in the milk, and also unlike baker's yeast, these small yeasts are not inhibited in their activity by increasing concentration of the cane-sugar; they are, in fact, capable of fermenting saturated solutions of cane-sugar in milk.

6. These yeasts do not appear to owe their introduction into the milk to the cane-sugar used.

7. Similar yeasts were traced back to the individual sources of supply of the milk in two cases.

8. It is not practicable to kill these yeasts by a high temperature at any stage during manufacture, as the resulting product becomes browned and depreciated in value. The company manufacturing this milk object (and rightly so) to the use of preservatives.

9. The only method open to prevent blowing is to ensure that the supply of milk, in the first instance, shall be clean.

10. By making more careful examination of the milk supplied, and by rejecting "dirty" milk, a considerable improvement in the manufactured product was attained within a few months.

XVI.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1905. By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Professor of Zoology in the Royal College of Science for Ireland, and Consulting Entomologist to the Royal Dublin Society.

(Plates XXVII.-XXXI.)

[Read, May 15; Received for Publication, May 18; Published, July 21, 1906.]

CORN PESTS.

Stem Eelworms.

Tylenchus devastatrix, Kühn.

Samples of Oats suffering from the "tulip-root" disease caused by these minute thread-worms were sent from the neighbourhood of Waterford in June. As the worms were described fully and figured in my paper of last year (4, pp. 285-8, fig. 2), it is unnecessary to do more than place their occurrence on record.

CABBAGE AND TURNIP INSECTS, &c.

The Cabbage Aphid.

Aphis brassicæ, Linn.

Leaves of Swedes badly infested with this well-known "greenfly" were received in August from Nenagh. Although usually found on the Cabbage and its varieties, this insect has been often noticed on Turnips. Curtis, in 1859 (8, p. 69), mentioned the insect as especially injurious to Swedes; while Theobald (14, pp. 93-4) has recently recorded its presence on Turnips in south-eastern England.

As is usual among the Aphidæ, the "viviparous" females, that are able to give birth without male assistance to active young, are the best-known forms of the species; and it is by the successive broods of these virgin females that the numbers of the aphids become so enormously increased, and the damage to the plants on which they feed so serious. There are both winged and wingless races of these virgin females. The winged form (fig. 1, *a*), which is about 1·7 mm. (about $\frac{1}{15}$ inch) in length, has the head, fore-trunk, eyes, and feelers black, the leg and cornicles dusky-brown, and the rest of the body yellowish-green. The wingless female (fig. 1, *b*) is somewhat larger; she has the body of a greenish-grey colour, with two series of eight dark spots on either side of the upper surface; the feelers are green with dark tips, while the legs, eyes, and short cornicles are deep brown. But both winged and wingless forms are so coated with a whitish, mealy secretion that the true colours of the insects are, for the most part, hidden. And it is the mealy coats of the innumerable aphids crowded on the leaves that catch the eye of the observer, and make this attack so easily recognisable.

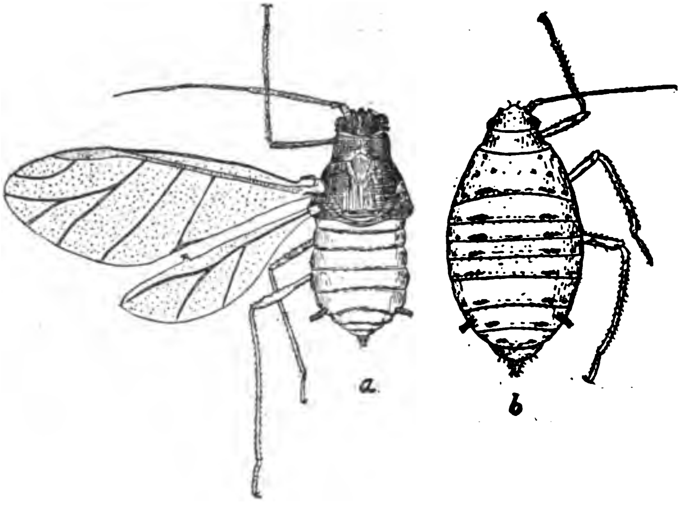

Fig. 1.—Cabbage Aphid (*Aphis brassicæ*): × 20. (*a*) Winged virgin female; (*b*) Wingless virgin female.

Much information as to the life-history of this aphid has lately been furnished by Theobald (15, pp. 86–90). The insects are first noticed on the leaves in May; and they do but little harm in the earlier portion of the year. By June the leaves begin to show small blister-like areas on the upper surface, the aphids sheltering and feeding in the corresponding hollows beneath the leaves. The sap which they suck is so considerable in quantity that the leaves become yellow and white, and, finally, in late summer the aphids swarm all over the plants, exposing themselves in multitudes above the leaves as well as below, and, by their sticky secretions, converting the whole plant into a repulsive mass.

When first born the young aphid is shiny and of a bright, yellowish-green colour; the mealy coating does not appear till after the first moult. The nymphs, that are destined to develop into winged females, are dull-green with the wing-rudiments dark-green or blackish-brown; their wrinkled cuticle is covered with a mealy secretion. Theobald, to whom we are indebted for these details, states that the transformation to the winged adult condition occupies from ten to sixteen days. He tells us that "the winged females may stay on the same plant and produce live young, or they may fly off to fresh plants. The latter does not usually happen unless the whole plant is smothered by the fly. As long as there is any food they seem disposed to remain."

In autumn the males and egg-laying females are produced, whose fertilized eggs serve to carry the species over the winter. The male (fig. 2, *a*) seems never to have been observed in these countries; but a description and figure of it have been published from American specimens by Weed (17, pp. 289–90, fig. 24). The body is 1·2 mm. ($\frac{1}{20}$ inch) long, and the wing-expanse 5 mm. ($\frac{1}{5}$ inch). The head and thorax are brown or black; the hind body light greenish-brown, with transverse rows of black spots on the back. The bases of the thighs are brown, and the rest of the legs black. The short cornicles are black, and so are the feelers (fig. 2, *b*), which have the third segment as long as the fourth and fifth together, but slightly shorter than the seventh. The autumn egg-laying female (fig. 2, *c*) is wingless, 1·8 mm. long, with an acutely-pointed hind-body, and more slender than the wingless summer female (fig. 1, *b*). She is pale-green, with the head, rows of spots on the back, feelers and legs of a dusky hue; the cornicles are black. Both sexes are covered with a greenish bloom. The eggs laid by these females are elongate, oval, and ·8 mm. ($\frac{1}{30}$ inch) in length. Of a light-green colour when first laid, they become black on exposure to the air. Weed states that they are laid "on the cabbage-leaves, especially in crevices and depressions"; but, according to Theobald's observations, it is on wild species of Brassica that they mostly occur in England; and he points out that such weeds "will always form a fruitful source of infection as long as they are allowed to exist in the immediate neighbourhood of cultivated lands." He writes further:—"That an active migration takes place between the wild plants and the cultivated can easily be followed."

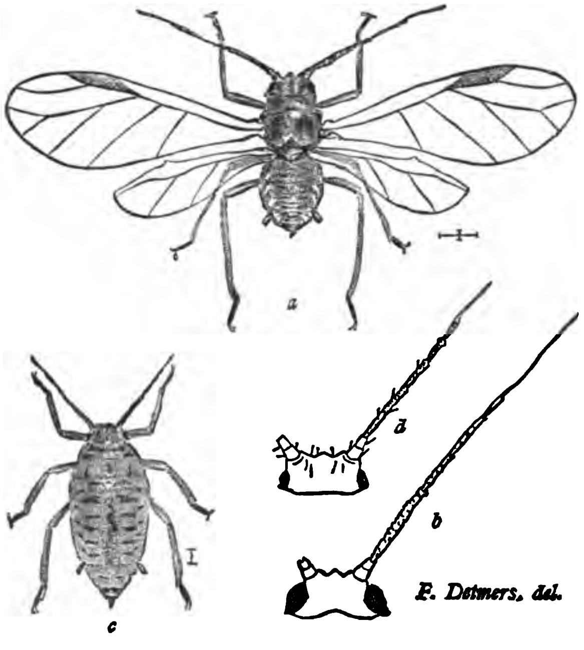

Fig. 2.—Cabbage Aphid (*Aphis brassicæ*). (*a*) Male: × 15; (*b*) Head and feeler of male: × 30; (*c*) Wingless female: × 15; (*d*) Head and feeler of female: × 30. From Weed, "Insect Life," vol. iii (U.S. Dept. Agr.).

Among the aphids were several specimens of a syrphid or hover-fly grub devouring them, while many aphids presented the hard, brown, shelly appearance which indicates that an ichneumon grub has fed within. Some of the ichneumon-flies were reared;

they proved to belong to the species *Aphidius rapæ*, Curtis (fig. 3), a member of the family Braconidæ, distinguished from the Ichneumonidæ by simpler wing-neuration, and containing a large proportion of the smaller parasitic Hymenoptera. In the genus Aphidius, which includes most of those species which attack aphids, the wing-nervures are markedly reduced in number. The present species is 2·25 mm. ($\frac{1}{10}$ inch) long. The male has feelers as long as the body, with seventeen segments; while in the female they are shorter, with only fourteen segments. The head and thorax are shining black; the feelers and hind-body dusky; the base of the feeler beneath the jaws and the stalk of the abdomen are yellowish. In the male the legs are mostly dark, with portions of the thighs, shins, and feet clear yellow; while in the female the legs are mostly yellow, with some dusky streaks.

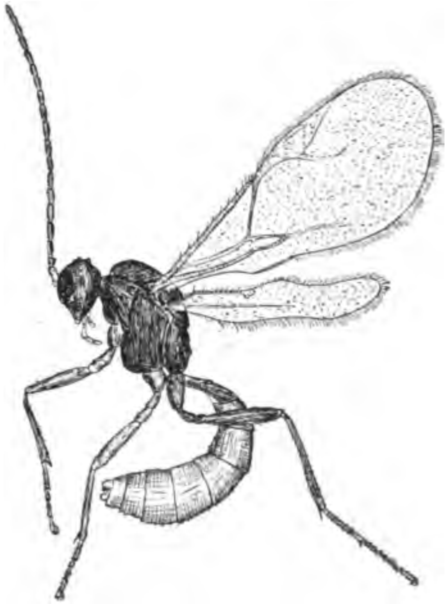

Fig. 3.—Parasite of Cabbage Aphid (*Aphidius Papæ*). Male: × 36.

In his monograph of the British Braconidæ, Marshall (9) described another parasite (*Aphidius brassicæ*) of *Aphis brassicæ*, and suggested that Curtis' *A. rapæ* might be in part identical therewith. The wing-neuration of Marshall's species is, however, still simpler than that of the insect described by Curtis, the cubital areolet of the fore-wings being absent.

These predaceous insects keep down the numbers of the aphids to some extent; but in seasons favourable to the increase of the aphids they fail to act as an effectual check. In taking measures for the destruction of the aphids, it is of great importance to begin in the early stages of the attack, when the leaves on which the insects are feeding, recognised by their yellowish and blistered aspect, can be cut off and destroyed by lime or burning. Later on, when the aphids have spread over the whole plant, little or nothing can be done. Spraying with paraffin and soap-emulsion is practicable in garden-plots, but is not profitable on large fields.

The Diamond-back Moth.

Plutella cruciferarum, Zell.

The last record of serious damage in Ireland by this well-known insect is to be found in my paper of 1901 (4, pp. 144-7), when the caterpillars appeared in numbers at several localities along our eastern coast. In August, 1901, Mr. J. Johnston, Agricultural Instructor for County Waterford, sent me leaves of Swedes from a farm in east County Wexford, about six miles from the sea. He stated that the greater part of a five-acre field had been ruined by the insects. An account, with figures of the moth, was given in the paper mentioned above.

The Cabbage-Fly.

Phorbia brassicæ, Bouché.

Every year brings complaints about this familiar pest. Roots of Broccoli injured by the maggots were sent to me in June from Tralee.

The Field Slug.

Agriolimax agrestis (Linn.).

Snails and slugs are often more injurious than insects to green crops in this country, and perhaps the most destructive of all is the small, mottled Field Slug (*Agriolimax agrestis*), which often appears in great numbers in damp weather. Eggs of this species were sent to me in November from Waterford by Mr. J. Johnston. They had been laid, as is usual, in a cluster, and close to the root of a Swede. The leafage of Cabbages and Turnips suffers especially from these slugs; but they attack all kinds of vegetation.

The family (Limacidæ) to which the present species belongs may be distinguished from our other native family (Arionidæ) by the absence of a caudal gland, and the somewhat backward position of the pulmonary opening (behind the middle of the mantle). In the genus Agriolimax the mantle is marked with concentric wrinkles, not with a deep, horseshoe-shaped groove (as in Amalia), and there are no lateral stripes or bands along the side of the slug's body (as in Limax). The hinder end of the animal has a dorsal keel (fig. 4).

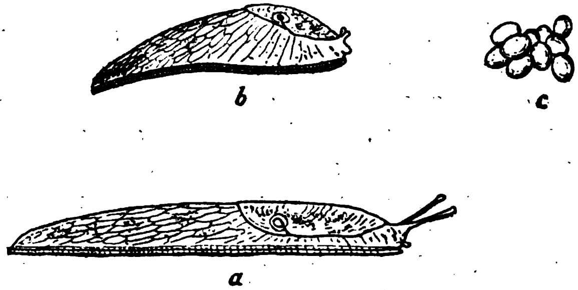

Fig. 4.—Field Slug (*Agriolimax agrestis*). (*a*) Extended ; (*b*) retracted ; (*c*) eggs : × 1½.

When *Agriolimax agrestis* is fully extended, it measures about 36 mm. (1½ inch) in length ; the mantle is about one-third the length of the body, and its mucous secretion is milky in appearance. The colour of this species is very variable. Usually it is yellowish with grey mottling; but it is often uniform grey or brown, and specimens from the western islands are sometimes quite dark. With respect to its feeding habits, Scharff (13, p. 528) remarks :—"The damage done by it in the garden, as well as in the field, is enormous. It begins its ravages in the evening, soon after sunset, and feeds the whole night through until the morning, when it retires for the day into worm-burrows, or underneath stones and clods of earth. It seems to be little affected by weather or climate."

The eggs (fig. 4, *c*) are almost globular and hyaline in appearance. They measure from 2 to 2·5 mm. in diameter. It has been stated that a single individual may produce over 300 eggs, which are laid in clusters of from 20 to 30. According to Collinge, egg-laying is continued from the end of March until the end of November (7, p. 16).

Dressings of salt or lime have usually been found most effectual in killing slugs. Theobald (16, pp. 209–211) recommends that salt should be applied at the rate of four or five bushels to the acre, and lime at ten or twelve bushels to the acre—two dressings being applied after sunset or before sunrise, at an interval of about a quarter of an hour, after heavy rain, when the slugs are active. The reason for the two dressings is that the slimy secretion of the slugs protects them from the effect of the first application, taking up the powder, and allowing the animals to escape. But they are unable to secrete a second lot of the protective slime after a sufficiently short interval. Rubbish-heaps and stones form an attractive shelter for slugs, and should therefore be cleared away as far as possible; while heaps of mould, which are often selected for egg-laying, may be advantageously dressed with quicklime. Rooks, starlings, and blackbirds often feed greedily on slugs, and thus assist in keeping down their numbers.

MANGOLD INSECTS.

The Mangold Fly.

Pegomyia betæ (Curtis).

As in 1904, this insect attracted notice in various parts of the country. Leaves, blistered through the presence of its maggots, were received from County Armagh in June, and from Counties Galway and Clare in July. An illustrated account of this fly, and the various stages in its life-history, will be found in my last paper (4, pp. 289–291, Plates XXIII., XXIV.).

POTATO INSECTS.

Potato Flea-beetle.

Psylliodes affinis (Payk.).

These little beetles—previously described and figured in the present series of papers (4, pp. 254-5)—were reported as again injurious to Potato-leaves in County Meath during June, and in County Antrim during July.

Ghost Swift-Moth.

Hepialus humuli (Linn.).

Potato-tubers growing in reclaimed bog-land near Enniskillen were attacked in March by caterpillars of this moth, which was described and figured by me in 1903 (4, pp. 195-7, fig. 1, Plate VII.A).

ORCHARD INSECTS, &c.

The Winter Moth.

Cheimatobia brumata (Linn.).

Plates XXVII. and XXVIII.

This moth during 1905 might have been regarded as the "insect of the year" from the economic point of view. My attention was first called to it during May, when Mr. T. S. Porter forwarded branches of Apple from County Fermanagh on which the caterpillars were ravaging the foliage. During June I noticed in demesnes in various parts of the west and south of Ireland several kinds of trees whose leaves were badly attacked by the caterpillars. For this insect is by no means exclusive in its feeding habits, and devours with avidity the leaves of many kinds of trees.

The moth (Plate XXVII.) is one of several species of the family Geometridæ, in which the wings of the female are so excessively reduced that she is unable to fly. The male has light-brownish forewings, densely sprinkled with dusky scales and traversed by dusky stripes; his feelers have bundles of strong bristles. The vestigial wings of the female are whitish-grey with darker markings. The outspread wings of the male measure 25 mm. (about 1 inch) across. As its name implies, the moth is abroad in autumn and winter, making its first appearance usually about the middle of October, while in some seasons individuals may be observed as late as January. The flightless females, after emergence from the pupa, which is buried in the ground, climb up the trunks of the trees on which the males seek them. Then they lay their small cylindrical eggs in groups at the bases of the buds or in cracks of the bark.

From these eggs the caterpillars are hatched in March or April, just when the young leaves of the trees are beginning to burst from the buds. The caterpillars are at first greyish in colour, but they soon become green or yellowish with a dark line along the middle of the back and a white stripe along either side, the head being mottled with brown or black. As usual with Geometrid caterpillars, the two hinder pairs of prolegs alone are developed, so that the caterpillar walks by "looping"—bending the long, central region of the body where prolegs are absent. But these caterpillars are rather stouter in build than most "loopers." They eat blossoms as well as foliage leaves, and trees on which they are present in large numbers are stripped almost completely (Plate XXVIII.). When fully fed—about the month of June—they let themselves down to the ground by silken threads, spun from the mouth, and pupate a few inches below the surface of the soil. From the underground pupa, as mentioned above, the moth emerges in autumn or winter, the female climbing up the tree-trunk to lay her eggs.

This habit of the moth enables orchard-owners to prevent the laying of eggs on the trees, and the consequent presence of caterpillars in the succeeding year, by the well-known plan of placing a "grease-band" around the tree-trunk, to serve as a trap for the ascending females. A band of grease-proof paper about 6 inches wide is tied carefully round the trunk with two pieces of string—one near the upper and the other near the lower edge—and is then covered with cart-grease not mixed with tar. The grease must be renewed periodically, so that the band may never get dry. The bands are best placed about 4 feet from the ground; they should be kept in order throughout the autumn and winter. If the trees are so young as to need supporting-stakes, these should be banded also (Ormerod, 11, pp. 162-4).

The only effective application for destroying the caterpillars when they are feeding in spring and summer, is some kind of arsenical spray; soapy emulsions are of little or no use. The two sprays generally recommended are "Paris green" and "lead arsenate." Paris green is an aceto-arsenite of copper; it should be obtained in the form of paste, and used at the rate of 1 lb. to about 200 gallons of soft water. The poison is not dissolved in the water, but remains in suspension, so that the mixture should be frequently stirred to keep the strength uniform. A fine spray is most effective, and the trees should never be "swilled" with the fluid. It has been found advantageous to add flour to the mixture, about 10 lb. to 1 lb. of the green.

Arsenate of lead is prepared by dissolving 1 oz. arsenate of soda in warm soft water, and mixing it with 12 gallons of soft water. After this a solution of 3 oz. acetate of lead is added, together with 1 lb. of treacle.

The Green Pug-Moth.

Chloroclystis rectangulata (Linn.).

The Apple-branches from County Fermanagh, which were infested with the Winter moth caterpillars just described, also harboured among the blossoms many caterpillars of the handsome little Pug-moth, *Chloroclystis rectangulata.* Both forewings and hindwings in this insect are green, with black or grey bands, while the abdomen, which is crested, has a blackish spot on either side near the base. The wing-spread measures about 18 mm. (¾ inch). The moths are flying about midsummer; and the eggs which the females lay remain unhatched through the winter. In April and May the caterpillars appear and begin to feed upon the blossoms. The caterpillar is of a yellowish-green colour, with a broad stripe either dark-green or claret-red down the back. These caterpillars feed on the petals of both Apple and Pear blossoms.

The December Moth.

Pœcilocampa populi (Linn.).

An unusual enemy of Apple-trees has to be recorded in this moth, whose caterpillars were sent from Newcastle, Co. Clare, at the end of May, with the information that they were proving "very injurious." They were feeding on the Apple-foliage when received.

The moth belongs to the family of the Lasiocampidæ, characterized by the feelers often comb-like in both sexes, the reduced sucking-trunk, the robust body, and the usually broad and ample wings of the moths, which are, as a rule, brown in colour. The caterpillars are robust and hairy, and spin an exceptionally dense cocoon for the protection of the pupa; whence their common name of "eggars." In the present species the wing-spread is about 38 mm. (1½ inch) or more. The forewings are markedly elongate, and the hindwings rather short; both pairs are thinly covered with scales giving a blackish-brown ground-colour, traversed by a white central line; the forewing is tinged with reddish-brown at the base and along the front margin. The moths fly in autumn and early winter rather late at night, and the eggs remain unhatched till the succeeding March or April, when the caterpillars appear, feed quickly, and become fully grown by May or June. The caterpillar is bluish-grey, with a double row of grey or brown, black-edged spots along the back, and a row of large black spots along each side. Further dashes of black and orange or crimson may be present in the dorsal region, and the under-surface is orange with black spots. Barrett (1, p. 3) gives oak, elm, birch, sallow, alder, hawthorn, lime, ash, aspen, and poplar as the usual food-plants of this insect, and mentions that the appearance of the caterpillar is admirably adapted for concealment as it clings to a branch of its tree. The red-brown pupa is enclosed in a dark grey-brown cocoon among leaves and rubbish on the ground at the foot of a tree, or a few inches below the surface of the soil.

The arsenical sprays mentioned above in connexion with the Winter Moth caterpillars would be found equally effective against the present insect.

The Pith Moth.

Plate XXIX., A.

Blastodacna vinolentella, Herr-Schäff.

Shoots of Apple-trees bored by the caterpillars of this moth were brought to me at the end of March, from Dennybrook, near Dublin, by Mr. T. S. Porter. This is a small moth (fig. 5, *a*) belonging to the great Tineoid group, recognisable by their elongate wings, which are—especially those of the hinder pair—bordered by long, delicate fringes. In the present species, which measures 10 mm. ($\frac{2}{5}$ inch) across the outspread wings, the head is blackish, and so are the forewings, except for a few white streaks and scales, while the hindwings are dark-grey (Meyrick, 10, p. 678). The allied species *B. atra,* Haworth, whose caterpillars feed during autumn on the berries of the hawthorn, seems to have been confused with the present moth, as both are included by many writers under the name *Laverna atra.* The true *atra* is characterized by a white (not blackish) head, and its larval habit is quite different.

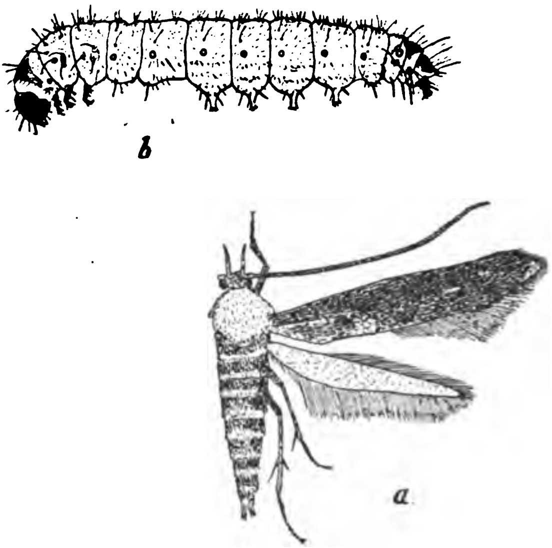

Fig. 5.—Pith Moth (*Blastodacna vinolentella*). (*a*) Male moth; (*b*) Caterpillar: × 8.

The moth is generally observed in July, and it is believed that the eggs are laid on the Apple-leaves, which serve as the earliest food of the larva. Towards the close of the year, while still quite small, the caterpillar bores into a shoot, and remains through the winter just beneath the bark. In early spring the caterpillars are to be found in the centre of the young shoots—hence the name "pith moth"—where their presence leads ultimately to the fading and death of the leaves. The small, round hole through which the young larva has bored into the shoot can be distinguished—usually close to the origin of a bud (Plate XXIX., A).

When fully grown, the caterpillar (fig. 5, *b*) is 8 mm. (⅓ inch) long, of a dull, fleshy-brown colour, with the head, first trunk-segment, and tail-segment deep chestnut-brown. Each abdominal segment carries six brown bristle-bearing spots. Towards the end of June the caterpillar pupates near the tip of the shoot in which it has fed; the pupa is yellowish, suffused with reddish-brown in front and behind. The moth emerges usually early in July.

No application (unless possibly an arsenical spray in late summer when the young caterpillars are feeding on the leaves) can be of any use against these insects, which live so well protected within the shoots. The removal and destruction of the injured shoots, with their contained caterpillars, in spring should be carried out wherever possible. The presence of the caterpillar is easily seen by the drooping of the leaves; and as this attack is most prevalent on young trees, the pruning of the damaged shoots is quite possible.

Wireworms.

Agriotes lineatus (Fab.).

Plate XXIX., B.

Wireworms—the well-known hard, elongate grubs of the click-beetles (Elateridæ)—are too well known to farmers as destructive to the roots of all kinds of field-crops. An exceptional case of damage due to them was brought to my notice in November by Mr. W. F. Gunn, who forwarded, from County Carlow, woody roots of Peach-trees gnawed and tunnelled by grubs of the best-known of all the species—*Agriotes lineatus* (Fab.). Mr. Gunn informed me that the wireworms had been almost cleared out of one bed by an application of the underground insecticide known as "vaporite," while an undressed border (from which the specimen forwarded to me had been taken) contained hundreds of the grubs.

The Gooseberry Saw-fly.

Nematus ribesii, Scop.

Specimens of the destructive caterpillars of this well-known Saw-fly were sent from Portlaw, County Waterford, at the end of May by Mr. J. Johnston; and from Mullingar early in June by Mr. M. Horgan, County Agricultural Instructor for Westmeath. In both cases it was stated that some of the bushes had been almost stripped of their leaves.

The female fly, which measures about 9 mm. ($\frac{3}{8}$ inch) in length, and has a wing-spread of 13 mm. ($\frac{1}{2}$ inch), has a black head, a yellow, black-spotted fore-body, and a clear, yellow abdomen; the legs are yellowish or whitish, with the tip of the shin and the foot-segments black. The male (fig. 6, A) has thorax and abdomen almost all black; he is rather smaller than the female. The flies usually appear early in May, and the female lays her eggs beneath the leaves both of gooseberry and currant bushes, cutting, near the larger veins, incisions in the lower leaf-skin, wherein the eggs are lodged. The caterpillars, like those of Saw-flies generally, have seven pairs of abdominal prolegs, in addition to the three pairs of jointed, clawed legs on the thoracic segments. The large number of prolegs serves to distinguish them from the caterpillars of moths, which have rarely more than five pairs. The caterpillar of *N. ribesii*, when first hatched, is 2 mm. ($\frac{1}{12}$ inch) long, greenish-white, with black head and black spots on the body-segments. In this young stage they feed in a company beneath the leaf in which the eggs were laid, and their presence may be detected by numerous small pin-holes piercing the leaf. It is of great importance to recognise, remove, and destroy infested leaves at this stage, as the insects will thus be killed before they can spread over the plant. If unmolested, they soon forsake the single leaf which can no longer provide food for them all, and migrate to other leaves and shoots. Through most of their lives the caterpillars are of a green colour, with black heads, and numerous black spots on the trunk-segments, the hindmost having, in addition, a large, central black patch (fig. 6, B). In its last stage, the caterpillar is about 25 mm. (1 inch) long, the black spots have disappeared, and the head is paler. The body is now of a green colour, with the first and hindmost segments orange. As they increase in size, the caterpillars become very voracious; and if they are present in numbers, they strip the bushes of all their leaves. They become full-grown about four weeks after hatching. Then they bury themselves an inch or two deep in the soil, and spin oval-brown cocoons (fig. 6, c) within which they turn to pupæ. After a pupal stage of three weeks, the flies become fully developed, and make their appearance to lay their eggs in the leaves, and start a fresh life-cycle which runs the same course as before. The caterpillars hatched from the eggs of the second summer generation of flies bury themselves and spin cocoons, but they do not pupate for several months, and the flies do not emerge until the succeeding spring. It is this habit of the insect—wintering in cocoons a few inches beneath the surface of the soil—that indicated long ago the best means for preventing a recurrence of the attack. The earth around the bushes should be removed during autumn or winter to

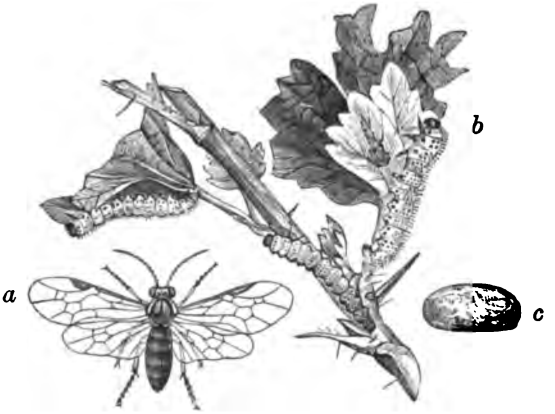

Fig. 6.—Gooseberry Sawfly (*Nematus ribesii*). (*a*) Male: × 3; (*b*) Caterpillars feeding: slightly enlarged; (*c*) Cocoon: slightly enlarged. From Ormerod's "Reports" (after Fletcher).

a depth of three or four inches, and buried deeply, being afterwards replaced by fresh soil. In this way the insects within the cocoons will be prevented from completing their development.

For spraying bushes during the feeding-time of the caterpillars, three applications have been found most effectual: hellebore mixture, Paris green, and London purple. But none of these poisonous insecticides must be used within six weeks of the fruit-gathering. An ounce of hellebore is mixed with 3 gallons of water and 2 oz. of flour; the mixture must be kept well stirred. The arsenical pastes (London purple or Paris green) must be mixed at the rate of 1 lb. to 200 gallons of water, kept well mixed while in use, and applied as a fine spray. To prevent disappointment, it must be remembered that the caterpillars must be allowed time to eat the poisoned foliage before they will die; and not until two or three days after spraying will they all be killed.

The Currant Root-Aphid.

Schizoneura fodiens, Buckton.

Soil from around the roots of Currant-bushes in County Waterford, that was brought to me in October by my friend Dr. G. H. Pethybridge, contained specimens of this aphid, which is mentioned by Buckton (3, vol. iii., pp. 94–6) as sometimes injurious to the roots of black currant. The wingless female is 1·4 mm. ($\frac{1}{18}$ inch) in length, globose and shining, of a ferruginous yellow colour, with the head rich brown. The eyes are absent or much reduced in size, and the cornicles on the abdomen are, as is usual in this genus, not developed as tubes, but present only as openings on the dorsal surface of the fifth abdominal segment. Besides this wingless form, nymphs with wing-rudiments were also present. These develop into the winged form, which is, according to Buckton, 1·8 mm. in length, of a shining-brown colour, with a slaty-grey abdomen. Buckton records that he discovered twenty individuals of this species in a nest lined with cottony fibres.

Kainit, which, hoed into the soil, has been found effectual against the root-living form of the "American blight" Aphid (*Schizoneura lanigera*), might be tried if the present species were found to be seriously injurious.

Strawberry-Eelworms.

Aphelenchus fragariæ, Bos.

Plates XXX. and XXXI., A.

In the month of May Mr. E. D'Olier kindly supplied me with Strawberry plants from Bray, County Wicklow, apparently suffering from the "cauliflower" disease described in 1891 by Ritzema Bos (2, p. 1) and Ormerod (12, pp. 126–133). The appearance of one of the plants is shown in the accompanying photograph (Plate XXXI., A). The stems become greatly swollen, and the buds, stunted and crowded together, remain in an undeveloped state (presenting the appearance of a small cauliflower), or give rise to monstrously deformed blossoms. Examination of the plants revealed the presence of numbers of small Nematode worms, which were found, on examination, to agree closely with Ritzema Bos' description and figures of *Aphelenchus fragariæ*.

The genus Aphelenchus is nearly allied to Tylenchus, to which belongs the well-known species that causes "tulip-root" disease in Oats. Both genera contain many species of minute Nematodes ("eelworms"), possessing in the mouth a spicule with swollen base, by means of which they pierce the plant-tissues that supply them with food. But while in Tylenchus the gullet is prolonged behind the swollen muscular pharynx, and forms a second swelling just in front of the intestine, in Aphelenchus, the intestine begins immediately behind the pharynx (Plate XXX. *p.*). The excretory vessels of Aphelenchus open just behind the pharynx, relatively farther forward than in Tylenchus. The male Aphelenchus has no bursa around the genital opening such as is usually found in Tylenchus. In most other structural features the two genera are similar.

In the present species (*A. fragariæ*) the male (Plate XXX., A) measures about ·6 mm. in length; the female (Plate XXX., B) ·75 mm. or more. The genital opening of the male is, as usual, far back, close to the anus, while the vagina of the female is about one-third of the body-length from the tail-end. Specially characteristic of the species are the constriction of the tail-region just behind the anus, and the narrowness of the front end of the intestine just behind the gullet.

The outbreak of this disease recorded by Miss Ormerod in 1891 occurred in south-eastern England (Kent). I am not aware that it has since been noticed in the British Islands, and it is certainly new to this country. Mr. D'Olier has kindly informed me that the plantation now affected was made in August, 1903, on ground which had been used for Potatoes and Rye-grass alternately for more than twenty years. Probably the worms were brought to the land with runners from plants already affected, but in the new plantation 45 out of 225 plants were diseased. "Royal Sovereigns" were worse than any other variety. Sulphate of potash was applied without any beneficial result, and ultimately the injured plants were all burnt, and the soil dressed with lime.

White Ringed-Worms.

Fredericia, sp.

Roots of Strawberries attacked by Enchytræid worms were received from Bray in November. Reference to the damage done to garden-plants by these worms has been made in my previous papers (4, pp. 202–3, 297–8).

Strawberry Click-Beetle.

Adrastus limbatus (Fab.).

A new enemy to Strawberries was noticed in July, when fruit in which the small click-beetle *Adrastus limbatus* was burrowing was received from Limavady. The genus Adrastus (of which *A. limbatus* is the only recorded Irish species) is closely allied to Agriotes, to which the common, destructive "wireworms" belong. Adrastus may be distinguished by the foot-claws being toothed; whereas in Agriotes they are simple. *A. limbatus* is an elongate beetle (fig. 7), measuring 6 mm. (¼ inch) in length, and only 1·5 mm. in breadth. The head and forebody are shining black, the latter with pale-grey hairs; while the feelers, wing-cases, and legs are pale ochreous yellow. This beetle occurs commonly all over Ireland, inhabiting, for the most part, clearings in woodlands, where specimens can be readily swept off the herbage on which they live. It will be of interest to see if there is any general tendency on the part of the species to make succulent fruits a common source of food-supply. On the present occasion it was suggested that traps in the form of sunken jars, baited with treacle, or other sweet substance, might be successful in catching many of the insects.

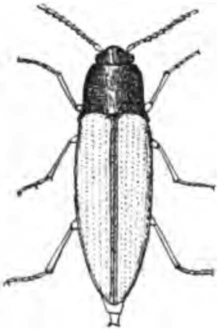

Fig. 7.—Strawberry Click-beetle (*Adrastus limbatus*) : × 10.

GARDEN INSECTS.

White Springtails.

Lipura ambulans (Linn.).

Every year seems now to bring records of injury by one or both of the species of Springtail mentioned in my former papers (4, pp. 251–3, 293–4). Specimens of the white species (*Lipura ambulans*) were received in April from County Armagh, with the information that they were damaging the roots of garden flowering plants and succulent vegetables. Lime and soot had in this case been applied to the soil without success.

Root Mites.

Rhizoglyphus echinopus, Furnouze & Robin.

Tulips attacked by these small mites were sent in May from County Kilkenny by Mr. O. W. H. Roulston. A description and figure of the mite, and an account of the injury which they do to bulbous plants, have been given on a previous occasion (4, pp. 258–260).

STORE AND HOUSE INSECTS.

The Rice Weevil.

Calandra oryzæ, Linn.

Plate XXXI., B.

A sack which had contained wheat imported from South Australia to Belfast was sent to me in November by my friend Mr. R. Welch. The sack was so full of Rice Weevils (*Calandra oryzæ*) that its inside appeared for the most part black. It was stated that the whole cargo had been similarly affected.

This species, and its near ally *Calandra granaria*, Linn., are frequently found among stored grain. They are specially common in ships' cargoes. The family of the Weevils (Curculionidæ) are characterized by the prolongation of the head into a prominent snout, from which the elbowed feelers arise, by the short, rigid, and conical palps of the first maxillæ, and by the feet with only four evident segments. The group of the family to which Calandra belongs comprises weevils with narrow bodies, and long, slender snouts. The weevils have rather short, stout, fleshy grubs, with wrinkled skin, and without legs (fig. 8, *b*).

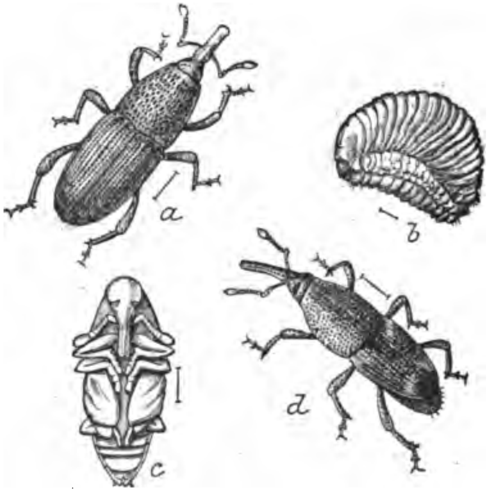

Fig. 8.—Grain Weevils. (*a*) *Calandra granaria*; (*b*) larva; (*c*) pupa; (*d*) *Calandra oryzæ*: × 8. From Chittenden, "Year Book," U.S. Dept. Agr., 1894.

Calandra oryzæ and *C. granaria* are each about 5 mm. ($\frac{3}{16}$ inch) in length. In both species the head and forebody are strongly punctured; but the puncturation is coarser in *C. granaria* than in *C. oryzæ*, which is narrower in the body (fig. 8 *a*, *d*). Both species are deep brown in colour, but *C. oryzæ* has two reddish spots on each wing-case, and *C. granaria* has a more shiny surface. *C. oryzæ* has the hindwings well developed for flight, but in *C. granaria* they are so reduced as to be useless.

The female beetle makes holes in the grains with her snout, and lays her eggs there—in wheat usually—one egg in each grain, and the larva lives inside, devouring all the internal food-supply of the seed. The whole life-cycle lasts about six weeks, and it has been computed that a single pair will give rise to 6,000 descendants in a year.

The results of some very interesting experiments on the conditions of life most favourable to these weevils have been lately published by Cole (6). A temperature of about 80° F. suits the insects best; frost is fatal to both species. *C. granaria* can endure a lower temperature than *C. oryzæ*; while the latter can stand a higher temperature than *C. granaria*—a result which might have been expected since India is the native country of *C. oryzæ*, though it has now been spread by commerce to all parts of the world. Moisture is absolutely necessary to the welfare of the weevils, which rapidly die in a dry, ventilated atmosphere. *C. oryzæ* does not succumb to dry conditions so quickly as *C. granaria*. The most surprising result of all is that the beetles thrive best, and will only breed freely, in an unventilated atmosphere that has become surcharged with carbonic acid gas. Even in air containing 80 per cent. of CO_2 some beetles lived for many days; and a fair proportion survived for fifteen days under the receiver of an air-pump at a pressure of only 1 inch of mercury, provided that water-vapour was present. Without the proof afforded by such experiments, it would hardly be believed that an insect could endure such an almost complete absence of oxygen. Sea-water is not fatal to the weevils. From these facts it is easy to understand how the hold of a ship is a most favourable environment for these insects.

The practice of removing the weevils and their excreta, together with the light, partially-eaten grains, from infested cargoes by sifting under a strong air-blast, before the grain is ground or sold, seems general among importers. In this connexion Cole points out that the grain thus screened contains numerous eggs and larvæ; and he had no difficulty, with favourable conditions, in rearing in about six weeks an innumerable multitude of *C. oryzæ* from barley which had been pronounced "sound" by practised Liverpool corn-merchants.

The Mottled Willow Moth.

Caradrina quadripunctata, Borkh.

The caterpillars of this moth are common in grass and on cereals during the harvest months, and they are often brought in with the crops and stacked in hay- and corn-ricks, where they find shelter for the winter. A curious and inexplicable case of the invasion of a dwelling-house by these insects was brought to my notice during September and October. Specimens were sent with the statement that during the last three years they had come in hundreds down the chimneys of a house at Kilbeggan, County Westmeath, making their way into wardrobes, drawers, and presses. Fires in the grates, and the burning of sulphur in the rooms, had not availed to banish them. It was said that for ten years past the surroundings and the condition of the house had remained unchanged.

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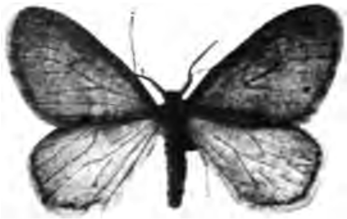
EXPLANATION OF PLATE XXVII.

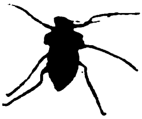
PLATE XXVII.

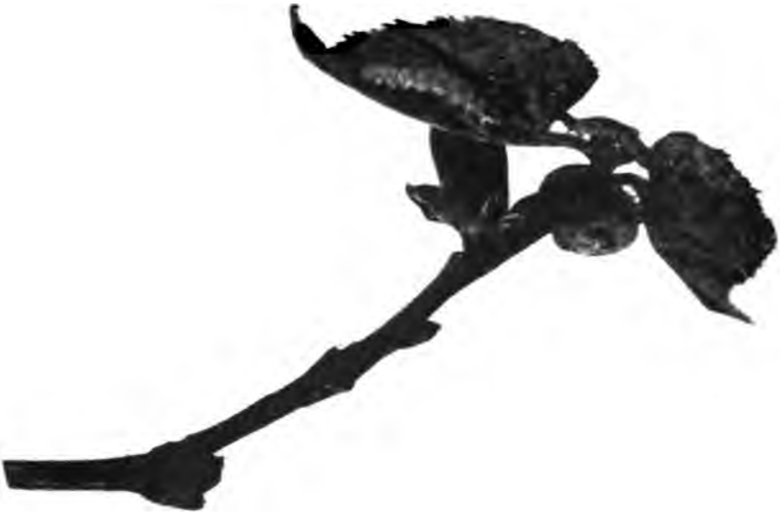
Winter Moth (*Cheimatobia brumata*, Linn.). Male (left). Female (right). Two Caterpillars feeding below. × 1½.

Photograph by T. Price.

PLATE XXVII.







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EXPLANATION OF PLATE XXVIII.

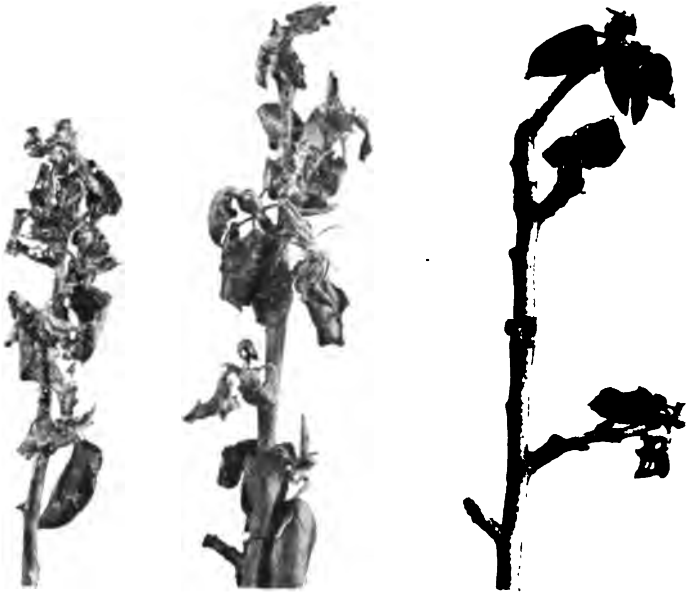
PLATE XXVIII.

A. Apple branches attacked by Caterpillars of Winter Moth (early stage).

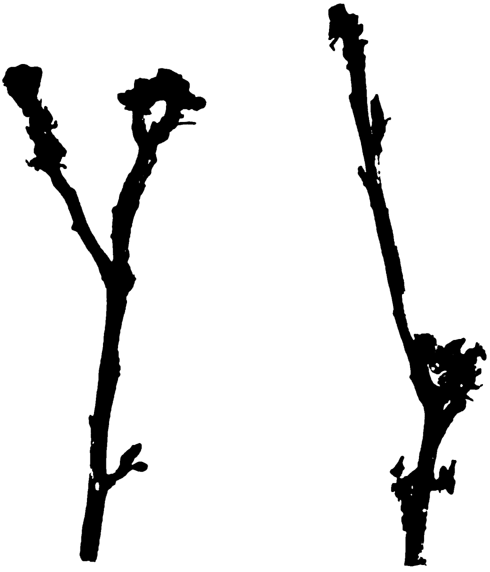
B. Apple branches (later stage), when almost stripped of leaves.

Photographs by T. Price.

A



B



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EXPLANATION OF PLATE XXIX.

PLATE XXIX.

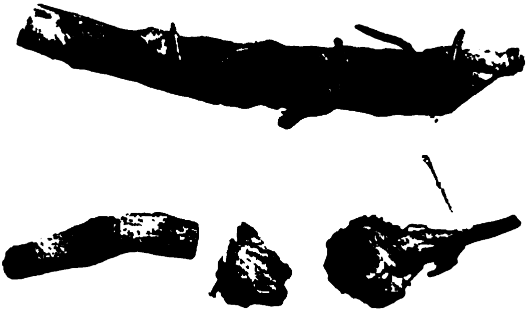
A. Pith Moth (*Blastodacna vinolentella*, H.–S.) with three injured Apple-twigs, showing (from left to right) entrance of young larva beneath bark, young larva feeding under bark, and older larva feeding in pith. Slightly enlarged.

B. Wireworms of *Agriotes lineatus*, Fab., feeding in woody roots of Peach.

Photographs by T. Price.

A

B



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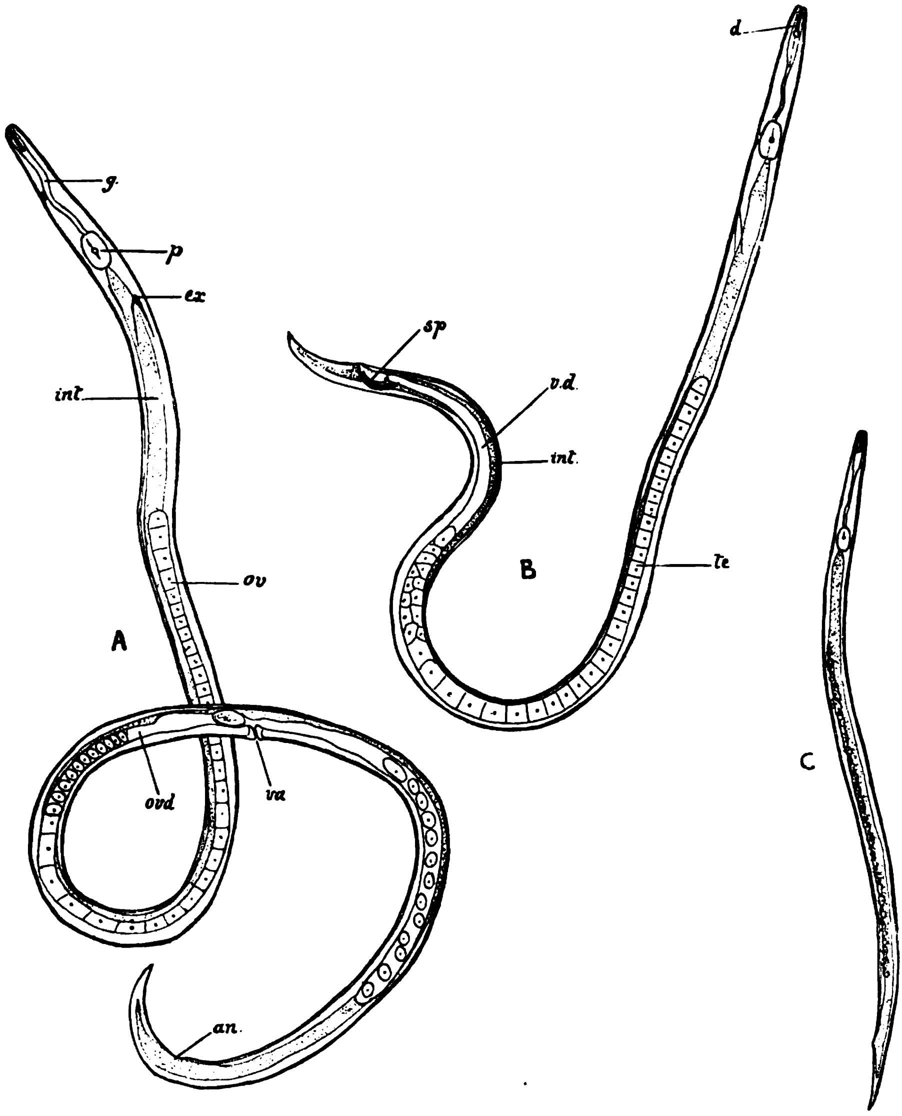
EXPLANATION OF PLATE XXX.

PLATE XXX.

Strawberry Eelworms (*Aphelenchus fragariæ*, J. R. Bos). × 360.
A. female ; B. male ; C. young.

d. stylet in mouth ; *g.* gullet ; *p.* pharynx ; *int.* intestine ; *an.* anus ; *ov.* ovary ; *ovd.* oviduct ; *va.* vagina ; *te.* testis ; *v.d.* vas deferens ; *sp.* spicules ; *ex.* excretory pore.



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EXPLANATION OF PLATE XXXI.

PLATE XXXI.

A. Strawberry Plant, attacked by Eelworms.

B. Corn-sack infested with Rice Weevils (*Calandra oryzæ*).

Photographs by T. Price.

A

B

M'Farlane & Erskine, Edinr.

XVII.

SOME INJURIOUS FUNGI FOUND IN IRELAND.

By T. JOHNSON, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.

(Plates XXXII.-XXXV.)

[Read, November 20; Received for Publication, November 23, 1906; Published, March 6, 1907.]

One cause contributing to the presence of disease in root and other crops in Ireland is the heavy rainfall, increasing in amount towards the west. As, however, the farmer learns to appreciate the benefits of a soil of the right degree of porosity, and to avoid by drainage a water-logged plant-bed, plant-diseases, due to fungal pests, fostered by excess of water and comparative lack of sunshine, should become less and less prevalent.

I propose, in the following pages, to call attention to some of the more important cases of disease which come before me for report, from time to time. An important part of the work of the Seed-testing and Plant-disease Station of the Department of Agriculture and Technical Instruction for Ireland is the identification of fungal plant-pests; and I hope readers of this paper will help in the supply of information, or of specimens, showing the presence of disease in their localities, so that steps may be taken for their investigation, and measures, where possible, recommended for their removal. Not the least important work of the Department's instructors is the unearthing of diseases of the crops of field and garden throughout the country.

YELLOW-BLIGHT.

Potato.

A variety of potato-plant absolutely proof against all the diseases to which the potato is liable has yet to be produced. The object aimed at—to produce a variety of such a robust constitution as to resist, or to be immune against, fungal attack—needs no commendation; and, judging from the rewards of many cultivators pursuing the object, does not need any artificial encouragement.

In 1905 the leaf-blight fungus *Phytophthora infestans* did relatively little damage in Ireland, thanks more to the dryness of the season than to the extensive use of the Bordeaux Mixture. A great deal of information is now available about this mixture from all points of view, and there is nothing to shake one's confidence in the mixture, in its originial form, or in one of its modifications, as still an effective and profitable remedy against leaf-blight. The mixture kills the fungus causing the leaf-blight, by the copper it contains. As the fertile threads, which cause the blight to spread from plant to plant, come out into the air through the air-pores or stomata, and as these occur on both the upper and under surface of the leaf (in the proportion of one on the upper to three on the under side) cultivators should take care that the spraying mixture is well applied to both sides of the potato-leaf. A form of the mixture has recently been tested, which seems likely to be serviceable in Ireland. The mixture is markedly adhesive and dries within a quarter of an hour of its application. It contains an alkaline sodium polysulphide. There are still many gaps in our knowledge of the leaf-blight fungus, *Phytophthora infestans*. The observation of Matruchot and Molliard, that, contrary to the generally accepted view, *P. infestans* does not cause a rot in potatoes, is of interest. Any rot, they state, found in a potato-plant suffering from leaf-blight attack is due to microbes which have become associated with the *P. infestans*. In a culture of *P. infestans* on potato, kept free from bacteria, no rot occurs. My own experience, gathered from the examination of innumerable specimens, both in the Station and in many different parts of Ireland, is that bacteria are far more responsible than *P. infestans* for disease, both in the field and in the store. Unfortunately we know of no such simple and effective remedy against bacteria as the Bordeaux Mixture has shown itself to be against the leaf-blight. All who have visited Connemara, or other parts of the west of Ireland, in the latter half of the summer, will have seen the yellowed foliage of the potato-crops, to which the name "Yellow-Blight" has been given. I have already written on this disease in the Journal of the Department of Agriculture and Technical Instruction for Ireland (vol. iii, September, 1902, to June, 1903). Worthington Smith, in 1880, was the first to record it in Britain, from Irish material. He describes it in "Diseases of Field and Garden Crops" as a "new disease" caused by a fungus named *Pesiza postuma* Berk. and Wills. Its most marked character is the presence in the potato-plant, in the hollowed-out stem, or on the surface, of black bodies resembling mouse excrement, and called *sclerotia*. In 1896 Prof. E. J. McWeeney, M.D., reported on the disease, practically repeating Worthington Smith's observations, and attributing yellow-blight to *Pesiza postuma*, or, as the fungus is now called, *Sclerotinia sclerotiorum*. As a matter of fact, yellow-blight is a term which applies to several different diseases, all agreeing in the yellowness of the foliage, due to the loss of nourishment to the leaves, owing to a block in the water-tubes and food-carrying vessels in the lower part of the plant.

For a long time, however, I also regarded *Pesiza* as the general cause of yellow-blight, and called it the 'Stalk' disease; but I had frequently seen microbes associated in the potato-plant with the *Pesiza*, and had had cases of yellow-blight in which the "sclerotium" stage was missing. I could not decide the extent to which the yellow-blight was due to the *Pesiza*, and how far microbes could be held responsible. Thanks to what I saw through Dr. Delacroix in France, where the yellow-blight occurs frequently, and where *Sclerotinia sclerotiorum* on the potato is unknown, I became satisfied that yellow-blight in the potato is more frequently due to bacterial work than to *S. sclerotiorum*, even when this latter fungus is present. It is necessary to distinguish the cases in which the yellow-blight is due to a microbe. Quite a number of species of bacteria have been discovered to have the power of causing yellow-blight in the way described. Thus, (1) in America, Smith has described *B. solanacearum*, which attacks also the tomato and the egg-plant; (2) in France (and Ireland), Delacroix, *B. solanicola*; (3) in Germany, Appel, *B. phytophthorus*, which also causes black-leg in potatoes; (4) in Belgium, Ritzema Bos, *B. septicus*; (5) in England

W. Carruthers, *B. solaniperda*. All these species have many points in common, so that though, biologically, it is important to note the distinctions between the different forms, their action in the potato-plant is practically the same, no matter by what name they are called. I am not at all satisfied that all these differently named bacteria in different countries are distinct. Appel gives definite directions for the identification of *Bacillus phytophthorus*. By following these in cultures I got clear evidence of the existence of this microbe as a general cause of yellow-blight, black-leg, and potato-tuber rot, in Ireland. It would be out of place, I think, to describe in detail in this paper the evidence on which these conclusions are based. I make this statement fully believing that, until it is realised that yellow-blight is much more due to *microbic* than to *Pesiza* action, little progress will be made in Ireland in stamping out the disease. Importers of Scotch seed should not overlook the fact that yellow-blight occurs in Scotland. In bacterial or microbic yellow-blight the attack may be delivered from without. The commonest way in which the disease appears is, however, by planting tubers with the microbe in them from a previously diseased crop. The soil may contain the microbe which enters the plant through the skin of the tuber, exposed through a wound caused by insect, or by spade in earthing up. The cut sets so generally planted invite the microbe to enter. It has been recently shown by Hume, in the United States, that the American form of yellow-blight (caused by *B. solanacearum*) is spread by leaf-biting and leaf-sucking insects, against which war, it is urged, must be waged.

If the circumstances are favourable to the microbe, that is, if moisture is abundant enough, and fresh air and sunlight deficient, the microbe thrives in the potato-plant, blocks up the veins at the base of the stem, prevents the passage of water and food materials from the root-system to the leaves, and finally causes the leaves to starve and turn yellow, so that they cannot do their work. The result is that often there are no tubers formed in a plant badly attacked by yellow-blight. The extent to which tubers are formed depends partly on the time at which the plant is attacked. One feature of the yellow-blight is far too much overlooked, and it is this, that in many tubers of a diseased plant the microbe has made its way into the tuber, where it is readily recognizable to the naked eye by the dark yellow streaks in the veins when the tuber is cut lengthwise through the heel. Such tubers go rotten, if not in the field then often during the winter, if not properly stored. Further, such tubers used as seed in the following spring propagate, as already stated, the yellow-blight. I am satisfied, from all I have seen, that the planting of such seed-tubers is one of the chief causes of the prevalence of yellow-blight in Ireland, especially in the western half of the country. Growers should secure, if possible, seed-tubers from a stock guaranteed free from yellow-blight in the previous season. Plate XXXII., fig. 1, shows how rapidly the microbe works destruction. I received some potato-plants from Mr. Rudd, from Co. Cork, which I found were suffering from *black-leg*. I infected healthy plants of Sutton's "Discovery," and within twenty-four hours the shoot had toppled over and was decaying, as seen in the figure.

Not only should healthy seed-tubers be planted, but they should be planted whole, uncut, and weighing about 3½ ounces. I know it is almost useless to give such advice, as the habit of saving their own, often diseased tubers (and frequently the worst of these), and cutting them into four or five pieces for planting, is too deeply rooted in the minds of Irish growers to be easily changed.

As these cut sets, with nearly the whole of their surface exposed, inviting the enemy to attack, are often planted directly in contact with manure, it is not surprising that the crops are often so poor, and plants which should be growing and tuber-forming, at any rate well into September, are 'houghed' and 'down' in many parts of the west by the middle of July. Cultures have shown that one or other of the microbes can attack other crops too, such as mangels, turnips, swedes, carrots, and beans. Oats, barley, and other corn crops are *not* attacked. If anything effectual is to be done, to prevent the constantly recurring cry of a potato famine in the West, very radical changes will have to be made, I think, along the lines I have indicated. I have seen numerous potato plots in nearly all the counties of the West, have examined a great many potato tubers, and I am quite satisfied that the present mode of procedure in reference to potato-growing is hopeless.

POTATO-LEAF SPOT OR LEAF-BROWN.

In 1904 Vañha described in detail a disease in potatoes causing great loss to growers in Bohemia and other parts of Austria, and occurring also in North Germany, Denmark, and Sweden. He states that the disease is probably much commoner than supposed, as its appearance is not unlike the ordinary leaf-blight. I have met with the disease in several parts of Ireland, and have also seen it in English-grown potatoes. Plate XXXIV., which I owe to Professor Vañha's kindness, gives a clear idea of an attacked leaf. The disease makes its appearance when the plant is in its optimum state of growth, in July or August, in the form of small blackish-brown specks, in the leaf-blade of the upper leaves. These specks increase in size and fuse together, until finally the whole leaf turns black, and dries up completely, falling off in the end. The specks are always sharply defined at their edges, without the white cottony border characteristic of the ordinary leaf-blight spot. The result is that the leaves die prematurely, and the tubers in consequence remain small, their number and size naturally depending on the time and extent of the attack. The fungus responsible for the trouble has been named *Sporidesmium solani varians*, Vañha. It is an excellent illustration of a pleomorphic species, because several different modes of reproduction of the fungus pest, all connected with one another, are obtainable, not only in the potato-plant, but by cultures, apart from the plant. In spite of the increase in knowledge of fungi, during the last thirty or forty years, the gaps are still enormous; and there is a large class, called "Fungi Imperfecti," which serves as a receptacle for fungi whose life-history is so incompletely known, that they cannot be otherwise located until their affinities are better known.

Of this class several forms are known as occurring on the potato-plant, such as *Macrosporium*, *Alternaria*, *Cladosporium*, *Phoma*. By repeated cultures Vañha has shown that all these fungi are connected with one another, and that they are, one and all, different modes of reproduction of the same fungus. My own examination of material from County Cork, &c., indirectly confirms Vañha, as I have found several of the stages, e.g., *Macrosporium*, *Alternaria*, *Cladosporium*, and *Phoma*, on the same plant. More time is required to test his work by the direct method of strict culture. It is unnecessary to enter into details as to the characters of the forms. Suffice it to say that all, except *Phoma*, are essentially useful as means of spreading and repeating the fungus in the same or adjacent plants, or potato-plots in the same season. The *Phoma* stage enables the fungus to pass through the winter, and to attack a potato-crop in the following spring. Even with all these stages known, the life-history is still incomplete; and I am now searching for the other hibernating, or ascospore, stage. It is impossible to say to what extent the disease is prevalent. It is a distinctly destructive one, and has come to me from different parts of Ireland. It includes potato *leaf-curl*. Vañha finds that the Bordeaux Mixture—the 1 per cent. solution—is a preventive, if applied in time, and if repeated after three or four weeks, should fresh spots appear. In view of the existence of the Phoma stage, the diseased potato-tops should be burned, as they harbour the disease-spores.

Prillieux and Delacroix describe a disease of potato-stalks in the neighbourhood of Paris, due to *Phoma solanicola*, which, both as regards description and measurements of the fruit and their spores (*i.e.*, pycnidia with conidia), may very well be a stage of the *Sporidesmium* disease. In the case of these authors the fungus was observed causing disease in the potato-stalks, accompanied by withering and death of the leaves, and consequent diminution of crop. Indirect support of this view is forthcoming from the actual examination of some diseased potato-stalks from County Dublin, showing *Phoma solanicola*. Cultures are now in progress to test the matter.

SPONGOSPORA SCAB.

In 1904, Mr. Brock, horticultural instructor in the Department, brought me some scabby potato-tubers from a garden in Monkstown. Microscopic examination showed them to be suffering from an attack of *Spongospora solani*, a fungus discovered and described first by Brunchorst, in 1886, as the cause of scab. It is really, except in Sweden, a rare fungus, found only once before in the United Kingdom (in England), and only rarely in Germany. It is allied to the slime-fungus, *Plasmodiophora Brassicæ*, the cause of finger-and-toe in turnips. I have seen its plasmodium stage, and succeeded in growing a scabby tuber from which the scab passed to the new tuber and made it scabby. *Spongospora solani* is of biologic rather than of economic interest. I have described my observations on it in a paper, read at the Conference of the German Society of Applied Botanists, this year, and shall not dwell further on it here. (Plate XXXII., fig. 3; Plate XXXIII., fig. 1.)

PHELLOMYCES SCAB.

Some of my readers will probably remember that I called attention to the very general presence in Ireland of a fungus, new to Britain, forming numerous minute, dot-like, black spots on the discoloured surface of the potato-tubers. These black spots I called, following Frank, their first observer, the sclerotia or resting bodies of *Phellomyces sclerotiophorus* Frank, which neither Frank nor I could induce to develop further, though I obtained potato-gelatine cultures full of sclerotia. Last year O. Appel wrote to me to say that he and Laubert had been so fortunate, after many failures, as to secure their germination, with the result that they were able to satisfy themselves that the fungus was identical in its fertile state with *Spondylocladium atrovirens*, discovered by Harz in 1871 on cut potatoes in Vienna, and not since observed. Some time before I heard from O. Appel I had noticed on a potato hyphæ carrying whorls or rings of jointed conidia, and I asked my assistant, Miss Hensman, to take care of the material, and to make a sketch of the specimen for subsequent identification, as I had never seen anything like it before. I have since seen it several times. As Appel states, the fungus shows erect-jointed, unbranched, stiffish hyphæ or conidiophores, arising not only from the creeping fungal threads in the skin of the potato, but also from the sclerotia themselves. On these conidiophores the more or less spindle-shaped, or obclavate, jointed conidia are borne in whorls (Plate XXXIII., fig. 2). The fungus itself is very common in Ireland. Appel and Laubert are now investigating its destructive powers, as they have reason to doubt the power assigned to it, of penetrating deep into the potato-tuber and causing rot there, as well as scab at the surface.

RHIZOCTONIA SCAB.

Perhaps the commonest form of potato-scab in Ireland, and the cause of a potato-rot, too, is that due to the fungus called *Rhizoctonia solani* Kühn, characterized by the presence of sclerotia on the tuber, and sometimes on the haulm. Rolfs worked at this fungus for three years in the United States; in 1904 he discovered its reproductive bodies, and showed that it is one of the mushroom group, the *Basidiomycetes*, and called *Corticium vagum* B. and C., var. *solani* Burt, under which name are to be sunk *Rhizoctonia solani* Kühn, and *Rhizoctonia violacea* Tul. I have previously reported that the "Rhizoctonia" scab can be prevented by soaking the seed-tubers in formalin. Rolfs recommends that the seed-tubers, after careful selection, should be treated with a weak solution of corrosive sublimate (30 grammes of the sublimate in 45 litres of water, or 1 oz. of sublimate in ten gallons of water).

The potato-crop in Ireland would be greatly increased if growers could be persuaded to secure, as far as possible, fresh seed, and to soak it beforehand in such a fungicide as formalin or corrosive sublimate.

FUSARIUM.

Another fungus which frequently does far more harm than is at present realised in Ireland, is one which is often regarded as merely a sort of carrion-fungus, as a saprophytic form living on potato-tubers already well advanced in decay, and on which it generally shows its presence in the form of raised pink or white spots. This fungus is *Fusarium solani*, one of several forms of *Fusarium*, a genus which is responsible for considerable loss in the flax crop; and in France, in violets. I have received from various parts of Ireland potatoes showing *Fusarium*; and, judging from Wehmer's infection experiments with *Fusarium solani*, this species must be regarded as a true parasite, capable of causing 'rot' in potato-tubers.

POTATOES IN STORE.

It is scarcely necessary to say that the destructive work, begun by the microbes and other fungi in the field, will be continued in the tubers in winter store, unless steps are taken to prevent the waste. Valuable investigations on the storage of tubers have been carried out at the Biological Institute at Dahlem, near Berlin, and a detailed report on the subject written by Dr. Appel. The two chief dangers to stored tubers are *frost and fungal diseases.*

The flesh of a potato-tuber freezes at a temperature 1° below that at which water freezes. When the temperature reaches – 3° C., then suddenly all the tubers become frozen. I have seen all the dug tubers left overnight in a field in County Mayo, destroyed by the one night's ground frost in October.

Where frost is the only danger, the tubers can be kept sound by taking the ordinary precautions against it. Here, as in Germany, rot of tubers is much more generally caused by fungi. High temperature, moisture, and the presence of dead or damaged potato are all specially favourable to the rotting organism.

Appel finds that, of the higher fungi, the most common and destructive is not the leaf-blight fungus, *Phytophthora infestans*, bad as it may be, but *Fusarium solani*, already mentioned. This fungus causes *dry-rot*, and is generally introduced into the store on diseased tubers from the field.

The bacterial rot is generally a *wet-rot*, and is most frequently due to the *Bacillus phytophthorus*, which is, as we know now, the cause of *black-leg*. Both the dry-rot and wet-rot groups of organisms are sensitive to dryness and cold, and so checked in their destructive work. Appel recommends that in a properly constructed store the temperature should not be allowed to fall below 34° F. (= 1° C.), should be kept as long as possible not higher than 46° F. (= 8° C.), and that, as far as possible, during the whole winter, the store should be kept thoroughly dry.

I have seen potato-pits in the West which, even as temporary stores, were perfect hot-beds of disease. Diseased tubers, with wet soil attached to them, were covered with wet sods, and then earthed over with wet surface-soil. When opened for me, after a week or two, the pit showed the rapid advance rot under such conditions was making. Last spring I collected information through the Department's instructors as to the mode of storage in different parts of Ireland. In some parts of the country the mode of storage as described is excellent, and there is very little or no rot. In others the reverse is true. In one county the bottom of the pit is sunk several inches below ground, and no provision for ventilation is made. Sometimes the potatoes are stored in the furrows between the lazy-bed ridges. Lime sprinkled through the tubers is recommended in one case. Mr. Jameson suggests the store should run north and south to get the benefit of the sun, and that the soil used in covering should not be surface-soil, but that got by digging two spades deep. In spring and summer he stores the tubers against a wall or in open sheds, covering the potatoes with bags and straw. Mr. M'Lurg surrounds his store with a trench 6 to 9 inches deep, and finds it helpful, the covering of the store or pie being straw and then soil. Mr. Marchbank and others lay stress on the necessity of digging the tubers in good time, before the soil is sodden, and storing them as dry as possible.

I shall now give a brief account of the main recommendations made by Dr. Appel:—The site chosen for the potato-store, 'pit,' or 'pie' should be, as far as possible, sheltered from the wind. The soil should not be too light, as frost penetrates such soil easily, and should not be one which holds water too readily. A good loam is best. There should be no actual pit or depression, as the water collects in the winter and enters the store, promoting rot. The floor of the store should be on the same level as the surrounding ground. In a sunk pit the potatoes in the lower part get much warmer than those in the upper projecting part. The pie should not be more than 5 feet wide at its base. Its length and height are of less importance, and may be suited naturally to the quantity of tubers to be stored.

Fig. 1 (page 356), taken from Dr. Appel's paper, shows the mode of construction of the store.

The potatoes to be stored should be carefully inspected, and the diseased or injured ones removed. When the crop is badly diseased, the seed-tubers for the next year should be carefully selected, and stored apart. [It would be, I think, much better in such a case to secure fresh seed. Diseased tubers can be kept stored for a time, if maintained near freezing-point.] The roof or cover of the pie or store is the most important part. First, one covers the potatoes with a layer of *straw—not potato-tops or sods—*

6 inches thick. [Mr. Jameson prefers dry rushes. He considers that oat-straw collects moisture.] On this is placed at once a layer of soil, 4 inches thick. These two layers form the first covering or roof, and are protection enough until the time comes when the frosts begin. By this time the temperature of the tubers will have fallen until they are only a few degrees above freezing-point. Then (and not before) the second covering is laid on. For this straw or similar material through which the air can pass readily is used. This layer of straw is 6 inches thick, and is covered by a layer of soil also 6 inches thick.

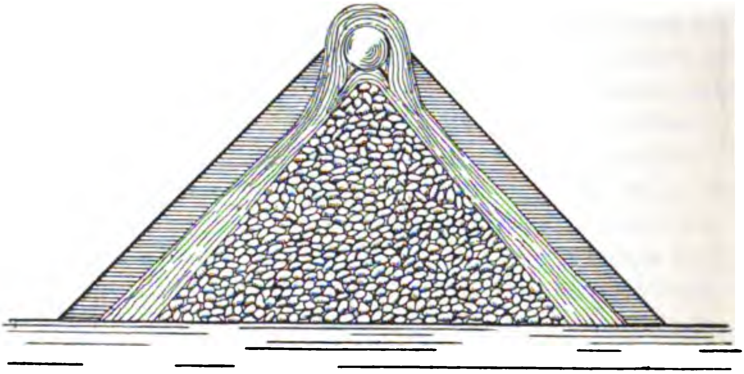

Fig. 1.

The double covering is found much more advantageous than the single one, as the cooling off of the store can be better regulated. A further arrangement to ensure proper aëration of the store is, I think, specially applicable to Ireland, where the tubers are often, of necessity, stored in wet weather, and, too often, with some rotting ones amongst them. A stout pole is laid along the ridge of the roof of the store on the first straw covering. This pole is then covered, as seen in the figure, with straw, and this is covered with soil to secure its ends. The pole is then pulled out, and so the hollow ridge or 'ridge-tube' of the pit is made. It remains open until the second covering is completed, and allows much moisture to escape from the store. Provision to get rid of more moisture can be made by putting in, at the bottom of the store, a lattice-work of wood (fig. 2), on which the lower potatoes rest, leaving a hollow space beneath them. Aëration is thus better secured, and the soil clinging to the potatoes, as it dries, falls through the lattice-work. In such a store as now described ventilation and the maintenance of a low temperature are provided for, and the loss from rot lessened, if not prevented entirely. The store should be kept intact until, in the spring, the outer air reaches a temperature of 10° to 12° C. (about 50° F.). The roof should then be taken off, and the contents used or transferred to open sheds. Appel lays stress on the taking of the temperature of the store from time to time, and suggests an arrangement for its observation very similar to that which I have seen in use in France for taking the temperature of tobacco undergoing fermentation. A tube, with slits in it at intervals, is inserted in the store lengthwise and slightly inclined. A piece of wood with a thermometer lying in a hollowed-out space at one end of it, lies in the metal tube, the open end of which is plugged with tow or other material. It is not necessary to have this arrangement in each pit. I ought to remind my readers that the winter temperature in Germany is much lower than in Ireland. At the same time Ireland's climate is so very much wetter that it might be better to raise the floor of the store above the general level of the ground, as recommended by Mr. Warnock, while taking all the other precautions.

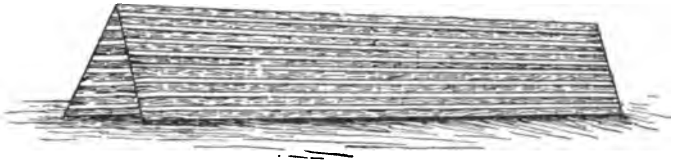

Fig. 2.

MANGEL HEART-ROT.

The heart-rot is so called because the disease causes the blackening and death of the younger central leaves of the mangel. From these it attacks the leaf-stalks and then the blades of the older leaves. In a pronounced case the mangel may become quite leafless. Sometimes the mangels, with change of weather, shake off the disease. In severe cases too, the mangel in the autumn rains puts out new leafy buds on the crown, a characteristic sign of the heart-rot disease. The flesh of the 'bulb' or 'root' becomes attacked too; cracks appear on its surface; the exposed surface turns dark, and on it, as on the leaves, small black specks appear, from which it is often possible to see, escaping, a short, fine, pinkish, worm-like thread. The black bodies are the common fruits—the pycnidia—of a fungus called *Phoma Betæ* Frank, or *Phyllosticta tabifica* Prill. et Delcx. The pinkish thread consists of millions of spores or conidia, each capable of causing disease in a mangel. They are the chief means of spreading the heart-rot. I have seen them at all times of the year, from autumn to spring, on diseased mangels, and am satisfied they can live through an ordinary winter in Ireland. The two French botanists Prillieux and Delacroix found the rarer ascospore fruit on dead leaf-stalks, in the late autumn, and thus were enabled to identify the fungus as *Mycosphærella tabifica*, one of the Ascomycetes.

At this stage the hibernation of the fungus also occurs. Its existence is an additional reason for collecting and destroying the decaying, diseased mangel-leaves, &c., of an affected crop. (I visited one field near Dublin, where the mangels were suffering from heart-rot. The worst roots had been gathered, and were being left in a corner of the field. They were lying beside a huge heap of manure intended for the adjoining field, in which mangels were to be grown next year. The farmer did not seem to realize that the men's boots, the cartwheels, &c., were all carrying the disease germs from the rotting mangels into the next field, and so introducing the disease into the mangel crop of the following year.) The *Phoma* stage may be found, too, on mangel seed-balls, so that the seedsman should see that the mangel seed he offers for sale comes from a healthy crop. It has been shown that the fungus cannot attack a sound mangel plant if the leaves are in full vigour, with abundant water supply, and if their leaf surface is uninjured. If, however, the mangel is suffering from drought, and the leaves are 'flagging,' then the fungus which is called a facultative parasite is capable of entering the mangel and causing rot in it. Mr. Horgan, knowing nothing of these facts, wrote that mangel rot was very prevalent in his county, and that the *dry weather* appeared to favour it. Sorauer suggests that as irrigation of mangel fields is out of the question, and one cannot always select, for mangel-growing, a field which does not suffer from drought, it is better to postpone the sowing of the mangel seed until as late as possible in the season, so that the mangel plants may be small, and not have too great a leaf-surface exposed during the time when the rainfall is lowest, and leaf-transpiration at its maximum. The late sowing results in a diminution in the weight of the crop; but this is, he thinks, counterbalanced by the more nutritious nature of the mangel flesh, as the *Phoma* destroys or alters much of the sugar of the mangel, and so decreases the feeding value. Farmers often do not notice any signs of the disease until the mangels begin to go rotten on their hands in winter store. Experiments are desirable to see if treatment with such a fungicide as formalin, or the new and harmless form of sulphide of potash called *Chinosol*, can be successfully and safely used in arresting mangel-rot in the store. Heart-rot is doing great harm in Ireland, and often follows the attack of the crop by the mangel-fly.

ONIONS.

Some parts of Ireland—for example, the Foxford district—seem especially suitable for onion-cultivation. Other parts, however, are much troubled by fungal enemies. Mildewed onions have been sent from the counties of Cork and Sligo. From Sligo I have received diseased onions, from time to time, from Mr. Aitken, who tells me that several tons of onions have been destroyed by the pest in his district. The onions in store become more or less covered with a white or greyish mould, shrivel up as seen in Plate XXXIII., fig. 3, and are ultimately worthless. I satisfied myself by cultures that the mould was the cause of the disease, getting all stages in the attack upon onions, from the first effects of the sprouting spores of the fungus to the collapse of the bulb. The fungus may first appear on the green leaves of the onion-plant, causing yellow spots, due to the effects of the penetration into the leaf of the fungus threads. On this spot a greyish-white mould appears, showing the spore-bearing threads of a *Botrytis*, similar to those found on the fleshy bulb-scales. From the leaf-spots the fungus threads pass through the leaf downwards into the bulb, and cause the bulb-rot, of which the outer indication is the patches of spore-bearing threads just mentioned. For some time I hesitated in the identification of the onion-mould between *Botrytis cana* and *Botrytis aclada*, when Lindau's article on *Botrytis* appeared, in which both these forms were suppressed and included in the variable *Botrytis cinerea.* There is everything to indicate that this stage is that called by Berkeley *Mucor subtilissimus.* As the onion-bulb collapses more and more, and in the end leaves the pest without any fleshy scales on which to live, the greyish-white mould gives place to firm, black bodies imbedded in the remains of the scales standing out on their surface. These bodies are resting forms of the fungus, and enable it to pass through the winter. They sprout out in the spring, and the spores they form attack onions where available.

This stage is that which is described under the name of *Sclerotium cepævorum.* It is not an independent genus, but simply one stage in the onion-mould. One troublesome feature in the onion-disease is its regular re-appearance year after year in the same bed, if onions are grown in it. It seems evident that some part of the fungus is left behind in the ground. On examining the roots of a number of diseased bulbs, I found that these, too, showed the mould, and on some I found sclerotia (see Pl. XXXIII., fig. 4). It is thus clear that, when the onions are pulled up in the ordinary way, many of the roots snap off; and, in the case of the diseased bulbs, some diseased roots are left in the ground, and these provide an easy means of propagating the onion mould from year to year. I made a number of experiments with tulips, hyacinths, and crocuses, to see if the onion-mould had any connexion with the fungus *Sclerotinia bulborum*, which causes such loss to bulb-growers in Holland and elsewhere. I repeated in 1905 the experiments started in 1904, but was not much more successful than Walker had been in a similar attempt. Massee, however, had been successful in the converse experiment, *i.e.*, in infecting onions with the spores or conidia of *S. bulborum*, and in producing what I am now describing. I am satisfied that we have in *S. bulborum* a fungus which is capable of causing disease in the bulbs of onions, tulips and hyacinths, and possibly lilies, and in crocus corms. The bulb trade is such an important one abroad, and this pest has caused so much damage, that it is not surprising to find that a great deal of excellent work has been done, both in the examination of the disease, and in testing methods of preventing it. Klebahn in Germany, and Ritzema Bos in Holland, have both added largely to our knowledge: curiously enough, they have not noticed the sclerotia on the roots.

The following are recommendations deserving attention:—

1. If the yellow spots begin to appear on the foliage leaves, spray with a weak solution of permanganate of potash, or of Bordeaux mixture.
2. Raise the diseased bulbs carefully (do not pull them up) to prevent the sclerotia falling off into the ground from the scales, and in order to take up the diseased roots as far as possible.
3. Examine the bulbs carefully when storing. Apparently healthy bulbs often show sclerotia hidden beneath the membranous scales, though most sclerotia occur in the root-disc region.
4. Disinfection of the soil with Carbolineum has been successful on the Continent. Liming the soil, and manuring with kainit, are also recommended.
5. Bulb-diseased beds should be given a rest for several seasons.

Sclerotinia bulborum appears to be independent of *S. trifoliorum*, the cause of clover sickness, and of *S. sclerotiorum*, already mentioned as a very common fungus in potato-disease, especially in the west of Ireland.

Carbolineum might prove economically successful in treating ground where potato yellow-blight is very prevalent.

AMERICAN GOOSEBERRY MILDEW.

Sphærotheca Mors-uvæ.

As is now well known, this mildew, which has done so much damage to the gooseberry and other species of *Ribes* in the United States, appeared in Ireland in a garden in County Antrim in 1900. Soon reports of its existence in other parts of the north-east of Ireland began to come in to the Irish Department of

Agriculture, and advice was given in each case as to the steps to be taken to eradicate the disease. Mr. Salmon has recently written strongly in the "Gardeners' Chronicle," because the Department did not immediately seek legislative powers to enable it to inspect the diseased bushes, and to insist on their destruction wherever found, especially in the nursery which is believed to have introduced the disease into Ireland, in gooseberry bushes imported from America. As the officer of the Department responsible for the investigation of fungal diseases of agricultural and other crops in Ireland, I have reported on many cases of the disease. To uproot and burn the bushes would no doubt be the surest way of stamping out the disease; but I could quote more than one case in which thorough spraying with the sulphide of potash (1 oz. in 2–3 gallons of water), as recommended by the Americans, or with Bordeaux mixture, has proved effective. I have, of course, nothing to do with the administration of the Department; but Mr. Salmon is in error in saying the Department has taken no action in the matter except, lately, to issue a leaflet (No. 76).[1]

Some time ago I started the accompanying map (fig. 3), showing by means of dots the distribution of the disease.[2] No. 1 indicates the place where the disease was first noticed. I should not have referred to the disease in this paper had it not been that considerable interest has been aroused by the discovery I made of the occurrence, for the first time in Europe, in 1905, of the mildew on the red currant (*Ribes rubrum*). It is now also reported on the red and black currant, and on the raspberry, as well as on the gooseberry in Sweden, and on the gooseberry in Denmark and Holstein.

As already mentioned, it is known on a number of species (cultivated and wild) of *Ribes* in the United States, and within the last few weeks Salmon has found it in England on gooseberry stock plants of *Ribes aureum*, imported from Germany. He urges the closing of the English ports to all importations of gooseberry bushes, and other species of *Ribes*, from Ireland and other countries, and the compulsory uprooting and burning of all diseased bushes.

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[1] One of its officers, *e.g.*, visited the suspected nursery, and the firm immediately burnt the diseased bushes he found there.

[2] The preparation of this map has been greatly facilitated by the information supplied by the Department through its horticultural instructors.

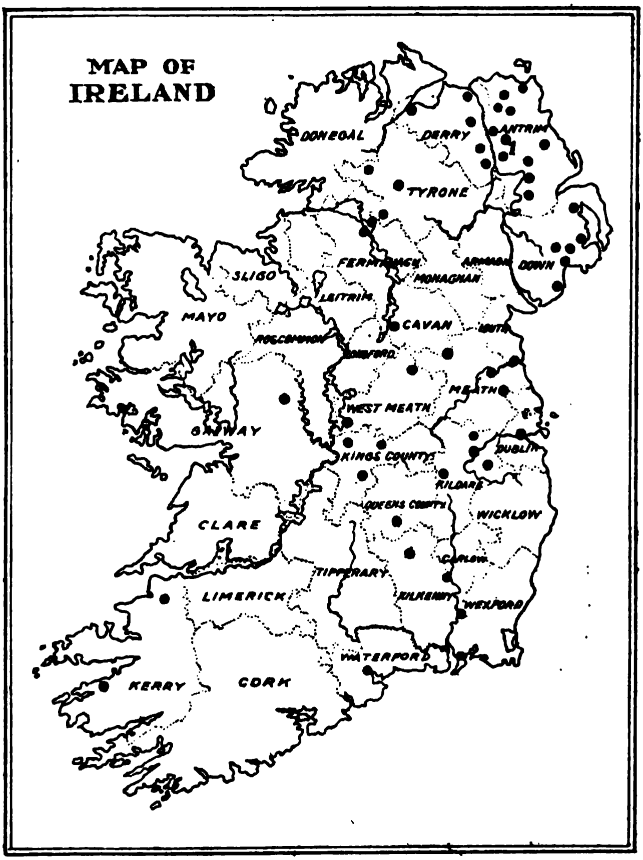

Fig. 3.

Map of Ireland showing distribution of American Gooseberry Mildew.

In to-day's paper, November 20th, 1906, an answer, as given in Parliament, is reported to the effect that though the English Board of Agriculture and Fisheries was aware that the gooseberry mildew had appeared in Ireland, with disastrous results, it had no power to prevent the importation of diseased stock into England. The importation of gooseberry stocks was in the hands of comparatively few nurserymen; and the Board would communicate with those firms, warning them of the danger of importing stocks from countries where the disease was known to exist.

I have before me, as I write, the illustrated leaflet on the mildew, prepared by my friend, Professor Aderhold, for the German Government. It is very much on the same lines as the leaflet prepared by me for our Department, and though the disease is, as I know, abundant around Hamburg and in other parts of Germany (having been imported, I was told, from Russia), I heard no suggestion that the German Government should order the destruction of nursery stock where found diseased, desirable as such destruction is. Let us now consider the red currant case. The diseased specimens came to me from Mr. H. de M. Fleming, of Barraghoove House, Goresbridge, County Kilkenny, in June, 1905. He reported that the disease was first noticed in his garden in 1901, on some gooseberry bushes, most of which had come, within the past twelve months, from an Irish nursery. It was not until 1905 that the disease became serious, and attacked the red currants too (variety unknown). Certain currant bushes (red and white) growing on a wall in the same garden, but some distance from the diseased gooseberries, were not attacked, and in 1905 bore good crops of fruit. Mr. Fleming, in 1905, sprayed his bushes four times with Bordeaux mixture (or the soda form of it), so that the upper and under sides of the leaves were well soaked in the fungicide until "the ground underneath was made blue," pruned thoroughly, repeated the spraying in the spring of 1906, and writes as recently as October 25th, 1906, that he has had a most satisfactory crop of gooseberries and red currants this year. He sprayed his bushes again this autumn, after the berries were gathered, and will repeat the spraying in the spring of 1907. He tells me the gooseberry mildew has occurred in several gardens in his neighbourhood. In some cases only has action been taken by the owners to stop the disease.

The most recent case of gooseberry mildew came to me through the "Farmers' Gazette," from the Duleek district in County Meath. The correspondent writes that in the autumn of 1904 he bought two dozen new bushes from the suspected nursery. In 1905 he noticed the mildew on the new bushes, and on one or two of the older ones. In 1906 he had a very fine crop of half-grown green gooseberries, which suddenly turned mouldy. A grower in the same district had an acre and a half affected, and thinks the bees must have brought the disease from his neighbour's gardens, as he has himself not introduced for years any new bushes into his garden, and has not previously seen the disease. The correspondent adds, "If the bees carry the disease, it is all over with gooseberry planting," partly, no doubt, because the bee-hives could harbour the pest.

In reply to an unofficial communication from me to the firm, calling attention to the frequency with which customers stated that the disease had first appeared in their gardens on bushes purchased from its nursery, and suggesting the desirability of taking action in the matter, the firm replied as follows:—

"We would like to point out that it does not follow that because the gooseberry bushes in question were supplied by us they were affected with the disease when sent from our nursery; and, as a matter of fact, we have never yet had a complaint from our customers; and, so far as we know here, the disease has not appeared in our nurseries at all. . . . We quite agree that prompt and drastic measures should be taken to stamp out the disease, if possible. Should the disease be found in our nurseries, we should not hesitate for a moment to sacrifice the whole of our stock rather than be the means of distributing diseased plants. Now that you have found the mildew on the red currant, it makes it more than ever necessary that the Government should step in, and adopt some measure calculated to stop the spread of the disease.

"We think it is incumbent upon the Government to send out competent inspectors to investigate and destroy all affected bushes. We will gladly submit our entire stocks to any competent authority; and if it can be shown to us that we have the disease in any form, we will destroy any affected stock without compensation of any kind.

"We feel certain our stock is absolutely clean; consequently we court the fullest investigation. As you are interested in this, if you find time, we will gladly show you over our entire stock for your investigation. We are quite as anxious as you or anyone else to have this pest stamped out of the country; but, to do so, our opinion is, that private gardens will require early consideration, and that investigation must not cease with nurseries or market gardens."

The letter emphasizes most clearly the necessity of Government inspection of nursery stock. This firm is anxious for a clean record, and does not know that it is, against its desires, probably harbouring the enemy.[1]

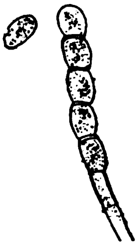

Fig. 4.

I have included, with the Department's permission, in this paper a Plate (Plate XXXV.), the coloured original of which was contained in the leaflet (No. 76) already mentioned. The other figures of the American gooseberry mildew, published in the leaflet, are also inserted here. The following remarks, with these illustrations, should enable anyone to recognize and deal with the trouble:—

In its early stages of attack the disease forms a flour-like coating on the leaves, twigs, and young fruits. Later, the white covering looks like a rusty-brown cobweb overgrowth, readily recognizable on the berries. In the flour-like stage the fungoid body consists of branching, cotton-like threads growing on the gooseberry plant, sending into its surface-cells minute suckers, and sending out from its surface innumerable upright threads which end in chains of spores or conidia (fig. 4). The spores fall off easily, and are carried by the wind, or other means, to other gooseberry plants and berries, which thereby become infected by the pest. The mildew may make its first appearance before the end-buds of the gooseberry shoots have burst, and when the ordinary green leaves are only half opened. It may destroy the young shoots completely, and cause great injury to the older shoots, so that no buds are formed for the following season, and the plant itself becomes so damaged as to succumb to the winter weather. As the white mealy stage gives place to the rusty-brown one the chains of spores disappear; and, in the dark, web-like overgrowth, other fruiting bodies make their appearance. These, with the dark web on which they grow, make the gooseberries very unsightly and quite unfit for use, causing them often to become shrivelled and misshapen. It is in the form of the dark, web-like growth, chiefly on the young shoots of the plants, that the fungus passes through the winter. The fruiting bodies produced are well protected by a thick brown coat, and each body contains eight spores (fig. 5). In the spring they burst, and the spores escape to attack the gooseberry plant, and form on it the floury coating.

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[1] Since the above was written, I have examined microscopically gooseberry twigs sent by the firm in question, and have found the American mildew in full fruit on these twigs.

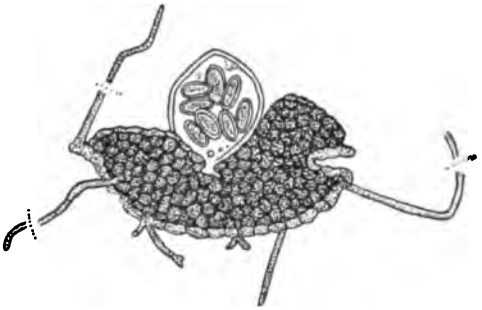

Fig. 5.

Prevention and Destruction.—As the mildew is a surface fungus, and is easily recognizable by the characteristics described above, growers should have no difficulty in noticing its first appearance. The safest step is to uproot and burn the attacked bush. Failing this, the plant should be sprayed thoroughly with a solution of potassium sulphide (not sulphate), in the proportion of one ounce to two gallons of water, and this treatment should be repeated at intervals of a fortnight. For subsequent sprayings, however, a stronger solution may be used, viz.:—two ounces of potassium sulphide dissolved in three gallons of water.

As the fungus exists during the winter on the branches and young twigs, the bushes should be given close spur pruning. The cuttings should be raked together and burnt. All the diseased and suspected plants should be sprayed in January with caustic spray (prepared and recommended in leaflet No. 55). As soon as the young leaves appear they should be thoroughly sprayed with a weak solution of the potassium sulphide (one ounce to two gallons). This should be repeated at intervals of two weeks, until the berries are well developed. When possible the gooseberries should be gathered green, and the stronger solution (two ounces of potassium sulphide in three gallons of water) at once applied to the plants.

The gooseberry is also troubled by another member of the mildew group which is called, to distinguish it from the other, the "European" Mildew, *Microsphæra grossulariæ*. It is generally confined to the leaves, on which it forms a grey-white coating. It has a conidial flour-like stage, and does not become brown like the American mildew. Its spore-cases appear as dark specks on a greyish background. I had specimens of it quite recently from Randalstown. The damage it does is not great as a rule, and is mostly confined to a premature fall of the leaves. Spraying should be undertaken where it becomes pronounced.

Another member of the mildew group—the Erysiphaceæ—is the species *Erysiphe graminis* which sometimes retards the growth of cereals. I have had it on experimental barley seedlings from County Cork. This case was in October, 1905, and may have been due to too early autumn planting. The mildew occurred in the same place in June on barley. Wet, unsuitable soil, spring frosts, &c., says Sorauer, favour the spread of the disease. All the mildews are surface fungi, and are thus easily accessible to treatment by sulphur powder or the other fungicides, such as Bordeaux Mixture.

SMUT.

The experiments which I carried out in 1901 for the Congested Districts Board on the prevention of oat-smut, of which a report appeared in the Society's Economic Proceedings (Vol. I., Part 3), hold good to-day. In 1905 a very interesting account of investigations into the smut of the cereals, by Brefeld, appeared. I have given a general account of these in *Science Progress* No. 1., 1906, and must refer readers interested to that article for particulars. Here I may briefly summarise the results, as they are of great importance to corn growers :—

1. The oat-plant is attacked by the smut in the seedling stage. The smut fungus, however, after entrance leads a concealed life in its host, and first reveals its presence by its dark-coloured spores when the oat is in ear. Thus fungicides and crop rotation are often effective means of preventing oat-smut.

2. In the case of wheat and barley the seedling is not attacked. The *flowers* give entrance to the pest, which shows itself first in the following season in the growing crop. Here treatment of the grain with fungicides is useless, because they do not reach the internal fungus-body, or mycelium, which has hibernated in the *apparently healthy grain*. Safety lies only in securing seed from crops *above suspicion*, as regards the occurrence of smut in the field.

BARLEY "LEAF-STREAK."

As long ago as 1901 my attention was called to a disease which had appeared in the barley experiments plots, started by the Irish Agricultural Organisation Society, under Mr. H. C. Sheringham.[1] The disease destroyed in most cases quite 50 per cent. of the crop, and has appeared more or less each year. I have had it from the counties of Cork, Tipperary, and Wexford. It is caused by a fungus called *Helminthosporium gramineum* Rab. which was shown only last year by Diedick and by Noack to have an ascospore stage, known as *Pleospora trichostoma*. The disease is increasingly recognized on the Continent as a source of damage to the barley crop. It is readily observable at an early stage in the barley, when it is from eight to ten weeks old, in the form of brown streaks on the leaves, and it may be called barley "leaf-streak." The streaks gradually increase in size until the whole plant dries up and withers away. In less severe attacks the barley plant forms its grains, which, smaller and more shrivelled than healthy ones, carry on the disease into next year's crop. It may be of interest to mention, as a result of our report, that the barley crops in England were examined by Mr. Sheringham, and nearly all were found to show more or less leaf-streak. A field of "Goldthorpe" near Berwick was found healthy. The grain, Mr. Hunter informs me, was purchased and the experimental plots of Goldthorpe have since been grown from it. The disease has not been so severe since 1901 in the plots, and when it occurs Mr. Hunter is inclined to attribute it to wet or unclean patches in the field. He has seen evidence of the passage over from one year to another of the disease by the use of infected seed.

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[1] These experiments are now conducted by Mr. Hunter under the joint action of the Department of Agriculture and Messrs. Guinness.

The stubble harbours the ascospore stage of the fungus which carries the pest over the winter in the field. The stubble should then be ploughed in deeply, or burnt. The straw is equally dangerous. Although treatment of barley or wheat grain by a fungicide is shown by Brefeld to be useless for smut, it is effective against "leaf-streak," and I would strongly recommend all growers to treat their cereals with a fungicide before sowing.

BARLEY-GRAIN BLACK-SPOT.

In 1904 I received samples of barley, grown in Co. Kilkenny, which had been rejected by a barley expert as unfit for malting, owing to the discoloration of the grain by the presence, in the form of dark spots, of groups of conidia of an incomplete fungus called *Alternaria tenuis* Nees, var. *Hordei*. The conidia are muriform or many-chambered and occur in chains. The fungus is usually associated with wet weather, and with the 'laying' of the barley in the field. Grain so contaminated, not fit for malting, should be treated with a fungicide before being used for seed purposes.

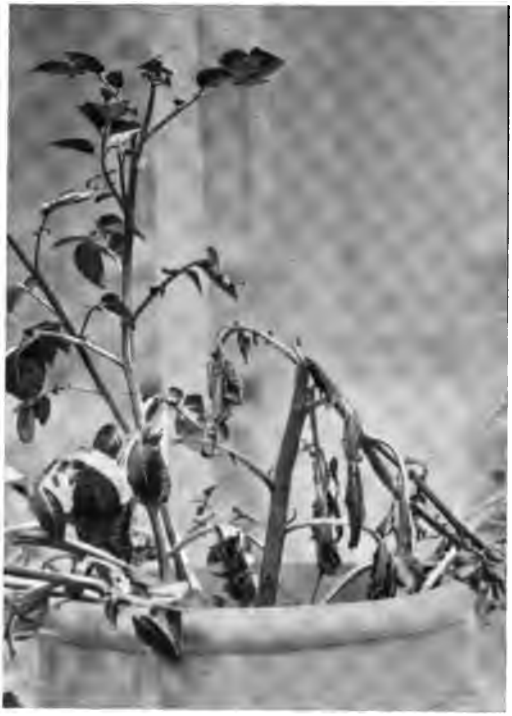
EXPLANATION OF PLATE XXXII.

PLATE XXXII.

Fig. 1. Photograph of Sutton's "Discovery" twenty-four hours after infection, from Co. Cork potato-plant suffering from Black-leg.

Fig. 2. Potato-slice, showing result of infection with black-leg microbe, *Bacillus phytophthorus*, after Appel's method.

Fig. 3. Potato, showing *Spongospora* scab on tuber and underground stem.



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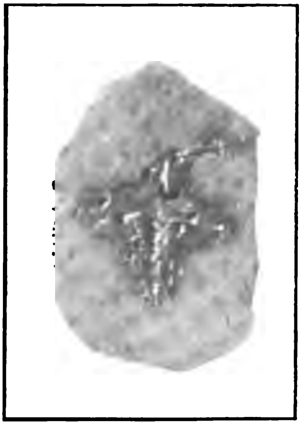

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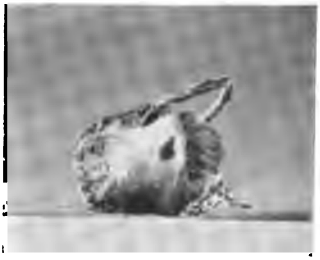

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EXPLANATION OF PLATE XXXIII.

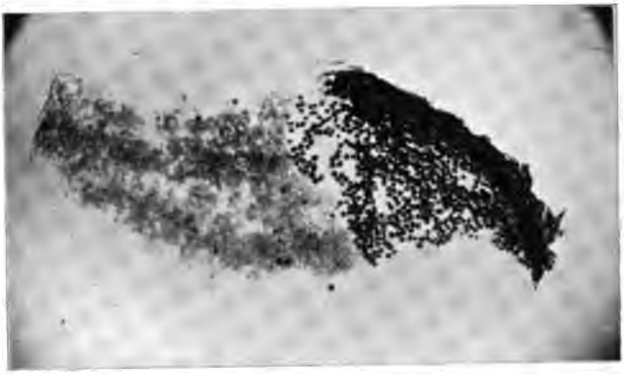
PLATE XXXIII.

Fig. 1. Photograph of section through a potato-tuber. To the left healthy starch-containing cells, to the right spore-balls of *Spongospora.*

Fig. 2. An upright thread (conidiophore) from the surface of a potato-tuber, showing the rings or whorls of jointed conidia of *Spondylocladium atrovirens,* Harz.

Fig. 3. Photograph of shrivelled onion bulb, showing the sclerotia of *Sclerotinia bulborum.*

Fig. 4. Photograph of root of onion, showing the root sclerotia.



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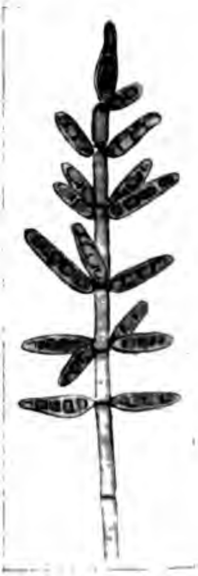

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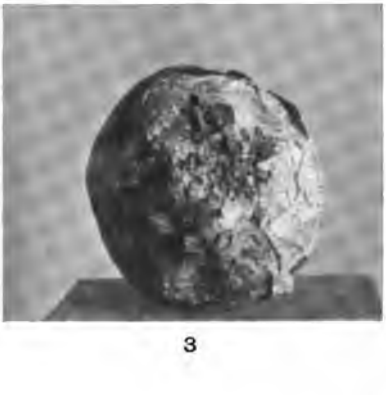

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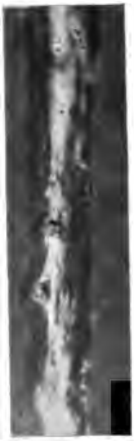

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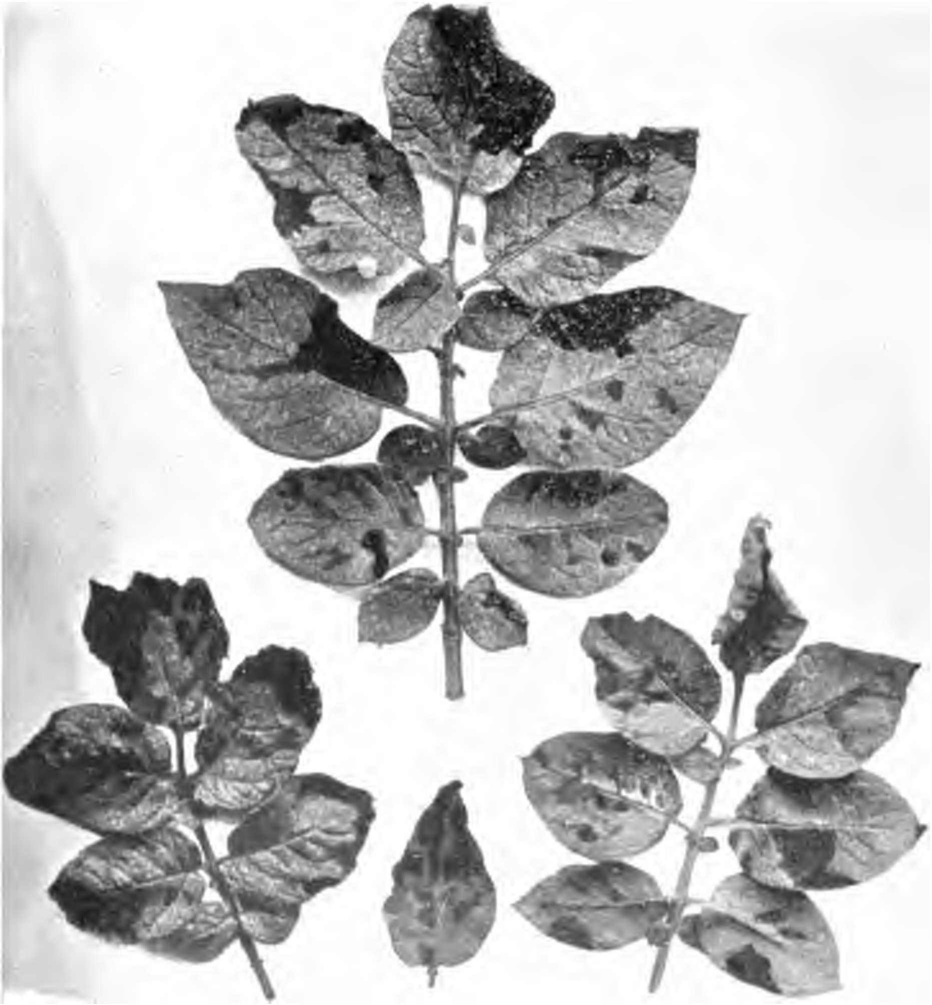
EXPLANATION OF PLATE XXXIV.

PLATE XXXIV.

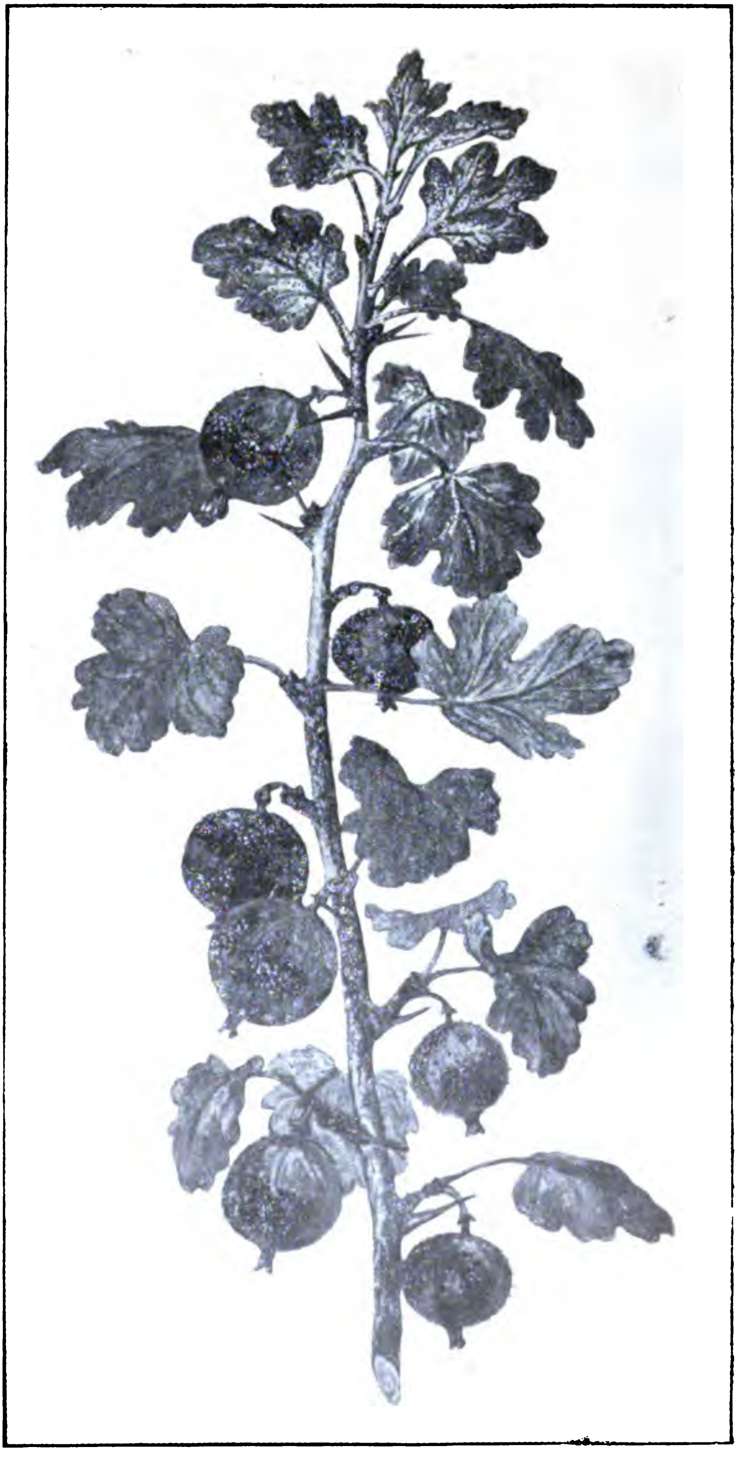
Photographs of potato-leaves suffering from *leaf-brown* or *brown-spot* (*Sporidesmium*).



EXPLANATION OF PLATE XXXV.

PLATE XXXV.

Fruiting gooseberry twig, showing the presence of the American mildew *Sphærotheca mors-uvæ* on leaf, twig, and berry.



XVIII.

REPORTS UPON THE IRISH PEAT INDUSTRIES: PART I.

By HUGH RYAN, M.A., D.Sc., University College, Dublin.

(Plates XXXVI.-XXXVIII.)

[Read, March 19; Received for Publication, March 22;
Published, July 6, 1907.]

Section I.—Irish Bogs, and the Methods Employed for their Reclamation.

1. *Preliminary Remarks.*

The provision made by the human race for one of its greatest necessities—a fuel supply—has varied from time to time with the conditions of its environment, and with the progress of its civilisation. For many ages almost the sole fuel employed was that which could be most easily obtained—wood. Later, as the wood supply became exhausted, coal usurped its place to the exclusion of turf, which, for reasons that will be enumerated more fully in a subsequent paper, was never really popular as a fuel.

The earliest recorded notice of the use of turf as a fuel is, perhaps, that given in the Natural History of Pliny (vol. xvi., p. 1), where, speaking of the inhabitants of a portion of North-West Germany, he says: "Ulva et palustri junco funes nectunt ad praetexenda piscibus retia; captumque manibus lutum ventis magis quam sole siccantes; terra cibos et rigentia septentrione viscera sua urunt." [They weave nets of rushes and sedges to catch fish; and form mud with their hands, which, when dried in the wind rather than in the sun, is burned to cook their food, and warm their bodies chilled by the cold north wind.] Thus the early history of turf starts in the district between the Ems and the Elbe. The use of turf as a fuel afterwards spread west of the Ems to Holland; and since that time these districts have formed the chief seat of the industry.

Although the use of peat as a fuel was thus early known, its employment at first, owing to the large supply of available wood, and later owing to the discovery of coal, was limited to the immediate neighbourhood of the great peat-producing districts.

In recent years the supply of wood has become too small in most parts of Europe to allow of its general use as a fuel; and owing to the enormous demand by the industrial centres for coal—a fuel so limited in quantity in these islands that its supply from the estimated known sources can scarcely meet the demand for a longer period than about 200 to 600 years—it is desirable that serious and well-considered efforts should be made to utilize the vast peat stores of Ireland in a rational manner.

2. *Enumeration of Attempts to Utilize the Irish Peat Supply.*

Many attempts have been made in this country during the past hundred years to accomplish this object. About the middle of the nineteenth century a turf-charcoal factory was established at Derrymullen by Rogers, which was, however, after a brief period of work abandoned. A similar fate awaited the turf distillation factory, established at Kilberry, near Athy, by Reece, under the guidance of Sir Robert Kane and Dr. W. K. Sullivan, in the year 1849. A bright future seemed to lie before this factory, which was the first of its kind in the world; but after a few years' activity the directors were obliged to close it.

At Derrylea, near Portarlington, in 1866, several thousand tons of press turf were made by a modification of Gwynne's method; and the factory, like the similar Continental factories, was, after a few years, obliged to close.

The oldest known process for converting wet peat by pressure into fuel was that employed by Williams, in 1844, at Cappoge, in the Bog of Allen. Similarly of dry press processes, the oldest was that of Gwynne, which was tried on a small scale at Kilberry, in 1855.

Again, so far as I have been able to ascertain, the oldest process for the manufacture of sieve turf was that of Buckland, which was worked on a large scale in the year 1863 at a factory near the town of Sligo.

In more recent years there have been established in Ireland many peat-moss litter factories, such as those of—

The Standard Peat Fuel Company, at Umaras, near Monasterevan, Co. Kildare.

The New Irish Peat Products Company, at Coolaney, Co. Sligo.

The Irish Peat Development Company, at Maghery, Co. Tyrone.

The Irish Peat Industry, at Inchicore, Co. Dublin.

Messrs. Connell & Co., at Ringsend, Dublin.

Colonel Dopping, near Ferbane, King's County.

Mr. Sherlock, at Rahan, King's County.

A peat paper factory was worked for a short time at Celbridge, by the Callendar Paper Company. There are also peat fuel factories at Kilberry (The Electro-Peat Syndicate), Umaras, and Maghery; and at Carnlough, Co. Antrim, there is a peat distillation factory under the control of a company (Chemicals, Ltd.).

It may, therefore, be safely said that this country has done in the past, and is still doing, pioneer work towards the solution of one of the most difficult problems in applied science.

3. *Assistance given towards the Development of Peat Industries by Various States.*

In Ireland there have been at various times considerable sums of money contributed by the State, indirectly, for the advancement of the turf industry.

One of the first accurate surveys, superficial and cubical, of the more important bogs of any country was that which was carried out in Ireland at a cost of £41,565 by Griffith, Edgeworth, Townshend, Longfield, Jones, Nimmo, and Aher, during the years 1809-1814, for a Commission, under the chairmanship of General Vallancey, consisting of Messrs. Richard Griffith (sen.), Foster, Gore, Hamilton, and Blackwood. The reports submitted to the Commission include general descriptions of mountain bogs; and accurate descriptions, with maps, of over one million acres of flat or red bogs—their mean depths, methods of drainage, and the systems proposed for their cultivation. In addition, they describe the various attempts made in this country to cultivate or plant the bogs previous to the year 1800. It is much to be regretted that the recommendation made by Edgeworth and Griffith that the State should buy and reclaim, by the proposed methods, a bog as near to Dublin as possible, was neither adopted by the majority of the Commissioners, for reasons which were quite insufficient, nor acted upon by the Government.

The Department of Agriculture and Technical Instruction have within the last few years made some experiments on what one may call the improvement of the farmers' fuel.

They employed the services of an expert to report upon the various Continental processes, and to select the machinery necessary for the carrying out of the experiments, which were subsequently performed at Inny Junction, Co. Cavan, and at Castleconnell, Co. Limerick. The chief object of the Department was to enable the rural population to win their natural fuel without much expenditure of labour, and thus give increased facilities for the development of agriculture. Almost all the countries of Europe have taken, and are taking, a keen interest in the development of the peat industries, proceeding on lines similar to those just described as being at present practised in Ireland.

The Minister for Agriculture in Prussia has founded a Central Moor Commission; and at Bremen there is, in addition to an experimental Bog Station, a Society for the Promotion of Bog Industries in Germany, both of which receive financial assistance from the State. Bavaria has a similar Peat Utilization Society at Munich, and subsidizes experimental Bog Stations at Karlshuld and Bernau, under the guidance of an official peat expert, who was appointed in 1894.

Austria has a special sub-section for peat in its Agricultural Department; and experts paid by the State conduct experiments, and give free courses of instruction on peat at Sebastiansberg, Laibach, Admont, &c. At Jonkôping, in Sweden, there is an experimental Bog Station under the control of the State; and at Flahult there is a similar institute controlled by the "Svenska Moorkultur Föreningen"; while at Markyrad there is a turf school under the direction of Aurep.

In 1901 the Swedish Parliament voted £5,600 for experiments with turf, and sent two experts to visit the principal turf factories of Europe, and report on them. In the following year the

Parliament voted a sum of £84,000 as a fund from which loans to turf-manufacturers were to be given.

The Norwegians have established a peat society or company at Christiania, and sent, in the year 1901, an expert to report on the peat industries of Europe and Canada. The Norwegian Government grant a subsidy of about £300 per annum to the society. In Denmark there are peat societies at Aarhus and Viborg; while the Government voted, in 1901, a sum of £3,800 to the peat industries. The Dutch Government and the provincial corporations have spent upwards of £2,000,000 in providing a suitable canal system for the peat districts of the country.

Russia places the State bogs at the disposal of manufacturers at nominal prices, supports experiments on peat, instructs the peasants in the methods best adapted for employment in the industry, promotes railways in the peat districts, and carries the materials necessary for the industry at preferential rates. A few years ago the State built, at a cost of about £75,000, an experimental factory at Redkino for the manufacture of turf charcoal.

4. *Origin of Peat.*

In earlier times various theories, which are now of little importance, were held as to the nature and origin of peat. Some writers held that peat was a mineral substance that owed its combustibility to "earth oil," resin, pitch, and similar bodies mixed with it. Others believed it to be a purely vegetable growth capable of reproducing itself.

Modern writers hold that peat is derived from vegetable matter by a slow but progressive change. The evidence in support of this view is so abundant that here only a small portion of it can be given.

Vegetable organic matter, peat, brown coal, lignite, and coal are composed of the same elements (carbon, hydrogen, oxygen, nitrogen, and sulphur), although these elements are present in the above-mentioned bodies in different proportions. So far, however, from this difference in percentage composition being an argument against the validity of the theory of their common origin, it forms, when correctly interpreted, a powerful argument in favour of that theory. A glance at the following table, giving the average composition of vegetable matter, peat, lignite, and coal, will indicate that the percentage of carbon gradually rises from 50 to 92 as we pass from vegetable matter to anthracite coal. Similarly the percentages of hydrogen and oxygen fall from 6 and 44 to 3·3 and 4·7 respectively.

—	Vegetable Matter.	Peat (dry).	Lignite.	COAL.		
				Staffordshire.	Newcastle.	Anthracite.
Carbon, ..	50	60	68	79·5	88	92
Hydrogen, ..	6	6	6	5·5	5·3	3·3
Oxygen (Nitrogen and Sulphur),	44	34	26	15	6·7	4·7
TOTALS, ..	100	100	100	100	100	100

It would appear from the analyses that the conversion of vegetable matter into peat must be attended by the separation of hydrogen and oxygen, and thus the percentage of carbon in the residue increased. Observation shows that the gases methane and carbon dioxide, which are rich in hydrogen and oxygen respectively, are found in considerable quantities not only in coal mines but also in stagnant pools where vegetable matter is being converted into peat; and in this way the increase in the percentage of carbon is easily explained.

Another line of argument employed is afforded by the finding of fossil remains in coal preserving the structure of the plants from which the coal has been produced in the course of many centuries. In several coal mines, for instance, trees have been found embedded in the coal, preserving the original form of the growing tree, but with the bark at least converted into coal, and still exhibiting the organic structure it originally possessed. Still more so is this the case with peat, which usually exhibits clearly the structure of the plants from which it has been formed.

The processes by which vegetable matter is converted into peat are in some cases so rapid as to permit of direct observation of the phenomenon. For example, although as a rule the growth of a bog is not more than about two feet per century, under favourable conditions in Hanover a growth of from four to six feet in the depth of a bog has been noted in the short period of thirty years, the peat being formed by the gradual decomposition of vegetable matter.

Finally, as early as 1828, experiments were made by Wiegmann, amongst others, on the artificial preparation of peat from rapidly decomposing vegetable matter such as cabbage, grass, &c., with a considerable amount of success.

5. *Varieties of Peat-forming Plants.*

Many observations have been made as to the nature of the most important peat-producing plants. As it is highly improbable that a time will come in the near future when attempts will be made to increase the available peat supply, except perhaps in the case of mountain bogs with such uneven surfaces for base that it may be more economical to allow the peat to reform on the exposed surface than to attempt its cultivation, these theoretical results will be dismissed as briefly as possible, more especially as this portion of the subject has been already fully treated by Professor Johnson in a communication made to the Society (Econ. Proc., vol. i., No. 1.) Mosses of the Sphagnum and Hypnum varieties are by far the most important of the peat-producing plants, partly because they grow very closely together, but chiefly because they possess in a high degree the capacity of absorbing water.

Moor-heather, reeds, rushes, sedges, water-grasses, wool-grass, dwarf pines, willows, may be also mentioned. In fact, all plants which absorb water easily and form a close matting over ground can take part in the formation of peat.

6. *Process of Peat-Formation.*

Very little is known of the method by which the plants are converted into peat, and that little consists of some knowledge of the conditions under which the change occurs.

The two substances which are necessary for the growth of peat are vegetable matter and water. A pool, for instance, may during summer shoot up a considerable quantity of water-plants which decay in autumn, and then become completely submerged. At the bottom of the pool, where the plant remains are out of contact with any appreciable quantity of free oxygen, the process of peat-formation begins. In the following year fresh plants are shot up, decay, and fall to the bottom ; and so on from year to year until the pool becomes filled with decomposed plants. As the plant-growth is most vigorous near the edges of the pool, the water is gradually driven towards the centre, where the formation of peat continues long after it has ceased at the edges. In this way the centre of the bog may be raised above the level of the surrounding moor. Even when all the water has been used up on a high moor the mosses can still continue forming peat by absorption of water from the fogs and mists round the mountain-top. A cool, moist climate is preferable to a very cold or very warm one for peat-formation. If very cold, the growth and decay of vegetable matter are too slow; and, on the other hand, if too hot, the water evaporates too rapidly to allow of any appreciable formation of peat.

Since very little is known of the chemical nature of the substances present in peat, a vast amount of scientific investigation remains to be carried out before we can form any adequate conception of the course of the changes which take place in peat-formation. The most important decomposition products of plants found in peat are ulmine, humine, ulminic and humic acids and their salts. The resins and waxy bodies of the plants apparently remain unchanged. The tannin of the plants partly remains and is partly converted into humic substances. Cellulose and pentosanes remain in small quantities, but are mainly converted into humic bodies. Peat contains a relatively large quantity of nitrogen (0·5 to 3 per cent.), which has accumulated notwithstanding the loss of free nitrogen in the reactions by which peat is formed, partly owing to loss of non-nitrogenous matter, partly owing to decay of animal organisms (mites, larvæ, &c.) present, and partly owing to absorption of ammonia from the air by the humic acid, and the subsequent conversion of the ammonium salt into a sort of albuminoid body.

Apparently the first change in the process is attended by the separation of methane, nitrogen, and water, as the following analysis by Websky of gas collected under a Sphagnum layer indicates:—

Methane, 43·36 per cent.; nitrogen, 53·76 per cent.; carbon dioxide, 2·97 per cent. Later on the oxygen is largely eliminated as carbon dioxide; and when this is the preponderating reaction, the conversion of the peat into brown coal and lignite may be said to have fairly started.

7. *Age of Peat.*

It is difficult to form a correct estimate of the length of time during which peat has been forming in a bog. The problem may be attacked in several ways; but none of them gives very satisfactory results.

Generally speaking, the less the amount of recognizable plant remains, such as fibre, or, in other words, the more amorphous the peat, the older it is. This is not universally true, because different kinds of plants take part in peat-formation, and some of them, such as wool-grass, resist decay much longer than others, apart from the fact that, owing to variation of conditions of environment, the rate of peat-formation is by no means uniform.

By noting the nature of remains of animals, such as those of the Mastodon and *Cervus megaceros*—many specimens of which were discovered several years ago by Mr. R. J. Moss in Ballybetagh bog—we may roughly estimate the age of the bog in which such remains have been found.

On the Continent many objects have been dug out of bogs which prove the great age of peat. Amongst these, two of the most interesting are the two bodies found in a Thuringian bog, from whose clothing it has been deduced that they were those of German merchants of the time of Julius Cæsar or of Augustus, and the mummy-like body in the Copenhagen Museum, which was found fastened to a pole in a bog at Heraldskioer in Jutland. According to Petersen, this mummy seems to have been the body of Queen Gunihilde, of Norway, who was enticed in 965 A.D., on a promise of marriage, to Denmark, by King Harold Blatand, assassinated and sunk in a bog in the above manner.

Without going beyond our own Museum in Dublin we can find abundant evidence of the great antiquity of peat.

The Natural History Museum contains many specimens of the bones of the great Irish deer, some of which were found by Mr. R. J. Moss and others in the bogs of this country; and in the Royal Irish Academy's collection in the Museum are many articles of the Bronze Age (1500-500 B.C.) or even earlier, which have also been discovered submerged in bogs. The latter include:—

(*a*) *Stone Celts* (found in many Irish bogs, e.g. Oughterard).
(*b*) *Stone Beads* (found in a bog near Westport).
(*c*) *Flint Knife*, with a peat-moss handle.
(*d*) *Lunette*, of period 1500–1200 B.C. (found in a bog near Ennistymon).
(*e*) *Gold Collars*, of period 700–600 B.C. (found in Tipperary bogs at Ardcrony and Borrisnoe).
(*f*) *Bronze Pins and Rings* (found in a bog near Derryhale).
(*g*) *Bronze Rings, Spear-head, Socketed Celt*, and *Gold Bulla* (found in the year 1840 at Kinnegore).
(*h*) *Bronze Socketed Celt* (found in an Antrim bog).
(*i*) *Bronze Candlestick* (found in the year 1904, 25 feet below the surface of a bog near Feenagh).
(*j*) *Willow Trumpet*, of Late Bronze Age (found in a bog on Lord Dillon's estate in County Mayo).
(*k*) *Trumpets*, of Late Bronze Age (found in a bog near Tralee).
(*l*) *Collar of Chain Mail*, of Early Iron Period (found in the year 1840, 3 feet below the surface of a Roscommon bog).
(*m*) *Iron Caldron* (found in the year 1884, 2½ feet below the surface of Drumlane lake bog, County Cavan).

There are also several specimens of early human garments in the collection, amongst which are:—

1. *Coarse Woollen Dress* (found in the year 1843, in a bog near Shinrone).

2. *Woollen Cloak*, *Coat*, *Tunic*, with *Leather Shoes*, probably of the seventeenth century (found in a Sligo bog).
3. *Tunic* (found in the year 1836 in a Tipperary bog).
4. *Otter-skin Hood* (found in 1861 in an Antrim bog).
5. *Coarse Woollen Garment*, of Late Bronze Age, as proved by objects found with it (from a bog in Antrim).

There is in addition a very interesting model of a dwelling, 12 feet square and 9 feet high, which was constructed of rude oak planks, and found 26 feet below the surface of Drumkelin bog in County Donegal. In the immediate neighbourhood of the house was a stone causeway, indicating that the house was originally a crannoge in the lake which afterwards became filled with peat.

8. *Classification of Bogs and of Peat.*

According to their positions on the earth's surface bogs are divided into three classes:—

1. *High* or *mountain bog*, formed chiefly by the mosses, heather, and wool-grasses, affords peat containing little ash, and with a good calorific power.
2. *Low* or *flat bog*, formed by grasses, sedges, rushes, gives peat containing more ash and of a lower calorific power than that got from mountain bog.
3. *Mixed bogs* consist partly of *mountain* and partly of *low bog*.

Peat may be classified, according to the nature of the plants from which it is formed most largely, as moss-peat, heather-peat, grass-peat, or wood-peat.

By others it is classified, according to its appearance when removed from the bog, into fibrous (moss)-peat, mould (mud)-peat, pitch-peat.

9. *Distribution of Peat.*

The distribution of peat over the surface of the earth is very unequal. Considerable peat-deposits are found only within the temperate zones, and even within that area the distribution is very variable. If the possession of peat is to be regarded as an important national asset, then Ireland is perhaps one of the most richly endowed countries in the world in that respect. Of its total area about one-seventh is composed of a peat layer varying in depth from two to forty feet. About three-sevenths of the Irish peat-deposits occurs as "mountain peat soil," the remaining four-sevenths forming the so-called "red bog." The "mountain bogs" lie mainly along the western coast, and the "flat bogs" in the great central plain. "Mixed bogs" occur in the other inland districts of the country.

In Germany about one-sixth of the surface of Hanover is covered by peat; while many smaller deposits occur in other portions of the country. Norway, Sweden, Russia, Holland, Denmark, and Scotland are also rich; while France, Austria, Switzerland, Spain, Greece, and Italy are comparatively poor in peat-deposits.

The estimated number of acres of peat-deposit in Ireland (3,028,000) is exceeded by that of Germany (5,600,000), but is much greater than that of Bavaria (185,000), of Austria-Hungary (100,000), and of Switzerland (12,000).

10. *Distribution of Bogs in Ireland.*

The flat bogs of Ireland lie mainly in the central portion of the island. If the total area of the Irish flat bogs be taken as twenty, then the belt of the country included between lines joining Howth Head and Sligo in the North, and Wicklow Head and Galway in the South, contains about seventeen parts, and of these twelve lie to the west and five to the east of the river Shannon.

In the Reports of the Bog Commissioners detailed descriptions of about 1,013,358 English acres of flat bog, and general descriptions of 459,090 acres of mountain bog, are given. The division of the bogs, in part according to the river basins by which they are or can be drained, adopted by the Commissioners, has not since that time been improved upon, and is retained in this paper.

A. *Flat Bogs of Ireland.*

		Acres.
1.	*Bog of Allen*, East of Figile River, in the County of Kildare	36,430
2.	*Barrow Bogs* in Kildare	41,075
3.	*Boyne Bogs* in Meath and Westmeath ..	42,370
4.	*Brosna Bogs* in King's County	44,594
5.	*Shannon Bogs* in King's County, Westmeath, and Longford	34,500
6.	*Inny and Lough Ree Bogs* in Longford and Westmeath	34,569
7.	*Lough Gara Bogs* in Mayo, Sligo, and Roscommon	83,689
8.	*Roscrea and Killenaule Bogs* in Tipperary, Kilkenny, and Queen's County ..	36,025
9.	*Maryborough Bog* in Queen's County ..	14,754
10.	*West Clare Bogs*	22,340
11.	*Barrow Bogs, 2nd Part*, in Kildare and King's County	7,459
12.	*Lough Corrib Bogs* in Galway and Mayo..	83,724
13.	*Mayo Bogs*	161,962
14.	*Lough Neagh Bogs* in Down, Armagh, Antrim, Tyrone, and Londonderry..	64,855
15.	*Iveragh Bogs* in Kerry	43,567
16.	*Kenmare Bogs* in Kerry	14,605
17.	*Laune and Lower Maine Bogs* in Kerry ..	17,990
18.	*Upper Maine Bogs* in Kerry	8,566
19.	*Cashen Bogs* in Kerry	31,514
20.	*Slieve Luaghar Bogs* in Cork and Kerry ..	32,902
21.	*Lough Ree Bogs* in Longford, Leitrim, and Roscommon	26,630
22.	*South Suck Bogs* in Galway and Roscommon	76,848
23.	*North Suck Bogs* in Galway and Roscommon	52,390
	Total	1,013,358

In the above list of Irish flat bogs no bog has been included

whose area is less than 500 acres; and thus it does not give a complete return of all the flat bogs in the country. For example, the County of Cavan, which contains 17,600 acres of flat bog, is not represented at all in the summary. Assuming that the smaller bogs of all Ireland have an area equal to ten times that of the Cavan bogs, the Commissioners estimated the area of the smaller bogs at 176,000 acres; to this must be added 97,000 acres of mountain "red" bog in Wicklow, 170,090 acres of mountain "red" bog in Erris and Tyrawley, and 192,000 acres of mountain "red" bog in Connemara, making a gross total of 1,648,448 acres of "red" bog for Ireland.

The mountain "peat soil" has been estimated at 1,380,000 acres, of which there are in:—

	Acres.
Kerry	500,000
Erris	155,000
Connemara	325,000
Donegal, Tyrone, and Fermanagh	400,000
Total	1,380,000

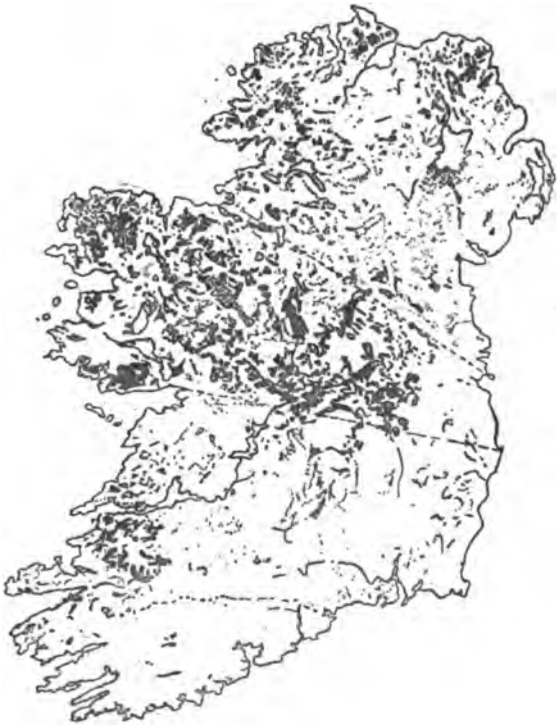
The total estimated or surveyed area of the bogs in Ireland is therefore—

	Acres.
Red Bog	1,648,000
Peat Soil	1,380,000
	3,028,000

and the average depth of the "red" flat bogs is about 25 feet.

There is a rather curious error in the final Report of the Bog Commissioners as to the total area of the bogs of Ireland. Owing to an oversight, the area of the bogs in Connemara, which was returned in Irish acres by the engineer, has not been calculated into English acres for inclusion in the general summary, so that the total area, 2,830,000 English acres, returned by the Commissioners should really be 3,028,000 English acres, as I have shown above. The point is, however, of no great importance, as the Commissioners were unable to complete the survey of the whole island, and besides laid no claim to accuracy in their estimate of the areas of the smaller bogs in the country.

It will be noticed that in the above summary I have followed the Reports of the Bog Commissioners in including the mountain "red" (or available) bog, of which there is a considerable quantity in this country, in the general summary of "red" (flat) bogs, and that I differ with preceding writers on the subject in calling, without qualification, the mountain "peat soil," so described in the Reports, available mountain bog. Very often the "peat soil" is only one "spit" thick, and on the average is under three "spit."



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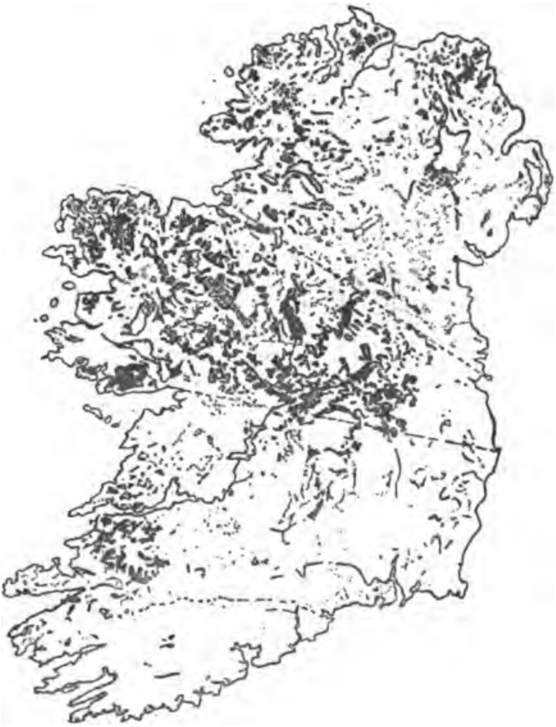

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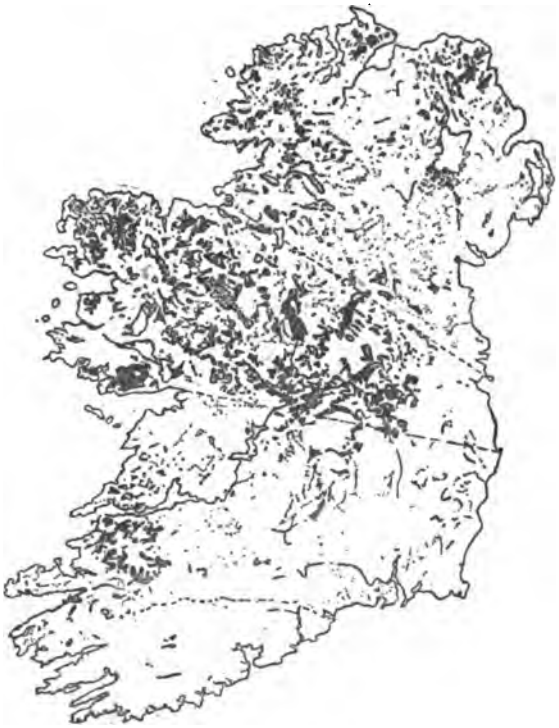

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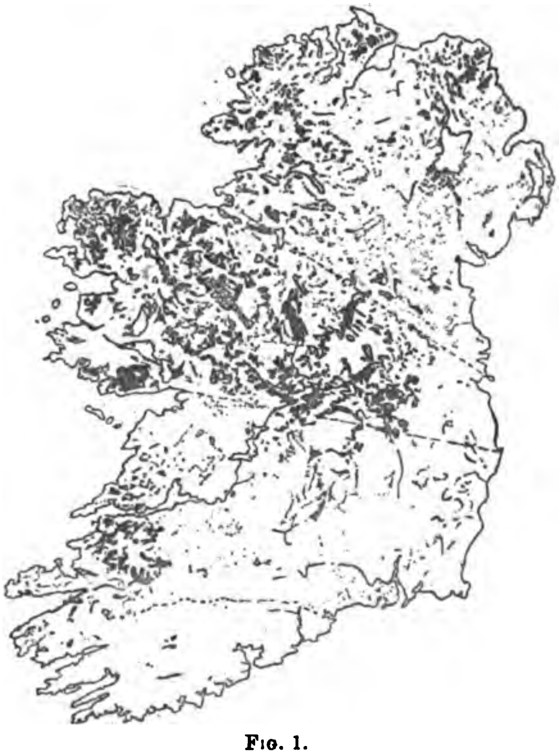

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whose area is less than 500 acres; and thus it does not give a complete return of all the flat bogs in the country. For example, the County of Cavan, which contains 17,600 acres of flat bog, is not represented at all in the summary. Assuming that the smaller bogs of all Ireland have an area equal to ten times that of the Cavan bogs, the Commissioners estimated the area of the smaller bogs at 176,000 acres; to this must be added 97,000 acres of mountain "red" bog in Wicklow, 170,090 acres of mountain "red" bog in Erris and Tyrawley, and 192,000 acres of mountain "red" bog in Connemara, making a gross total of 1,648,448 acres of "red" bog for Ireland.

The mountain "peat soil" has been estimated at 1,380,000 acres, of which there are in :—

	Acres.
Kerry	500,000
Erris	155,000
Connemara	325,000
Donegal, Tyrone, and Fermanagh..	400,000
Total ..	1,380,000

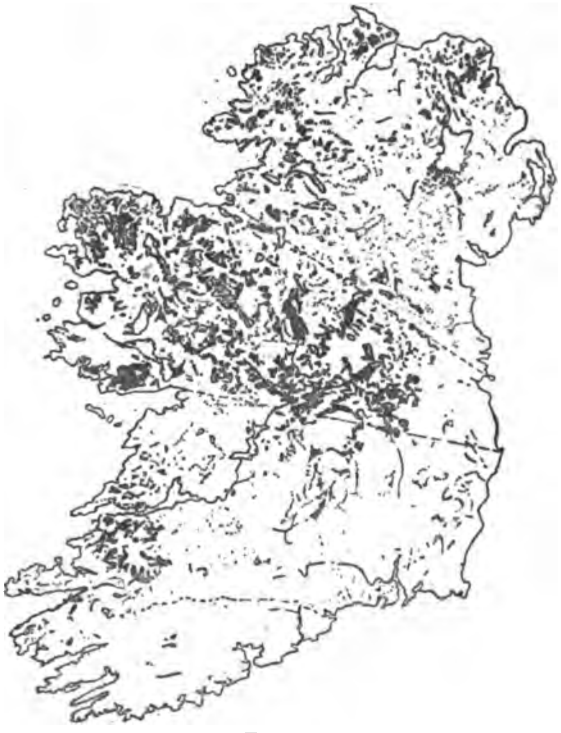
The total estimated or surveyed area of the bogs in Ireland is therefore—

	Acres.
Red Bog	1,648,000
Peat Soil	1,380,000
	3,028,000

and the average depth of the "red" flat bogs is about 25 feet.

There is a rather curious error in the final Report of the Bog Commissioners as to the total area of the bogs of Ireland. Owing to an oversight, the area of the bogs in Connemara, which was returned in Irish acres by the engineer, has not been calculated into English acres for inclusion in the general summary, so that the total area, 2,830,000 English acres, returned by the Commissioners should really be 3,028,000 English acres, as I have shown above. The point is, however, of no great importance, as the Commissioners were unable to complete the survey of the whole island, and besides laid no claim to accuracy in their estimate of the areas of the smaller bogs in the country.

It will be noticed that in the above summary I have followed the Reports of the Bog Commissioners in including the mountain "red" (or available) bog, of which there is a considerable quantity in this country, in the general summary of "red" (flat) bogs, and that I differ with preceding writers on the subject in calling, without qualification, the mountain "peat soil," so described in the Reports, available mountain bog. Very often the "peat soil" is only one "spit" thick, and on the average is under three "spit."



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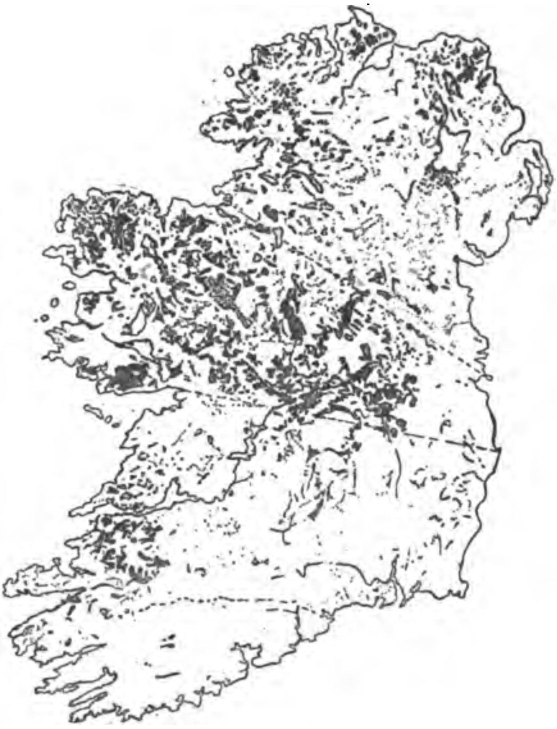

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Mr. Kilroe, for which I am indebted to the Department of Agriculture for Ireland, shows the positions in outline of the chief bogs mentioned above.

11.—*Composition of Peat.*

When taken from the bog, the peat contains from 80 to 90 per cent. of water, and from 20 to 10 per cent. of solid matter. On drying at the ordinary temperature, the percentage of water decreases to from 20 to 30 per cent.; and on further drying in a current of hot air, the turf may be rendered anhydrous. A small percentage of the dry turf consists of inorganic matter, which is left behind, when the turf burns, in the form of ashes. Two samples of air-dried turf from a mountain bog in Tipperary gave the following results on analysis:—

No. 1. A light surface turf contained when air-dry 29·17 per cent. of water, and had a specific gravity of 0·239, and contained ash to the extent of 3·69 per cent. calculated on the anhydrous turf.

No. 2. A dense turf contained 25·5 per cent. of water, had a specific gravity of 0·826, and contained in the anhydrous state 5·47 per cent. of ash.

The deviations in the appearance and behaviour of many specimens of turf are generally due to the different quantities of ash present. In some cases the percentage of ash may be as low as 0·5, and in others as high as 50.

If the percentage of ash in a given sample of turf is more than 25, the turf should not be used as a fuel. Less than 5 per cent. ash in a turf would be regarded as good, from 5 to 10 as moderate, and from 10 to 25 as bad. The principal constituents of turf ashes vary greatly with the nature of the soil on which the peat has formed, and usually consist of sand, compounds of the metals, calcium, aluminium, iron, magnesium, potassium, and sodium, with sulphuric, carbonic, phosphoric, and hydrochloric acids, silicon, and oxygen. The amounts of potash and soda salts in the ash are as a rule very small. The remaining portion of the dry ash-free turf—

that is, the organic portion—has an average composition of carbon (60 per cent.), hydrogen (6 per cent.), oxygen and nitrogen (34 per cent.). In some cases the percentage of carbon is much lower than 60, and in others above that number, as may be seen from some analyses of Irish turf published in the Proceedings of the Royal Irish Academy (1844) by Sir Robert Kane.

—	—	Ashes.	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Bog of Allen	Light turf from Cappoge	2·55	51·05	6·85	39·55
	Dense turf from Kilbeggan	1·83	61·04	6·67	30·46
Clare ..	Dense turf from Kilbaha	8·06	51·13	6·33	34·48

The most important of the organic substances present in peat are those vaguely called humic acid bodies. They include the substances known as humine, ulmine, humic, ulmic, and crenic acids, and "humic carbon," with another acid more or less soluble in water, to which the name apocrenic acid has been given.

The other bodies present include wax, resin, tannine, cellulose, and pentosanes.

Humic acid, to which the formula $C_{60}H_{54}O_{27}$ has been ascribed, is a brownish-black amorphous substance, or mixture of substances, which dissolves in aqueous alkali, and is reprecipitated by addition of excess of mineral acids. Ammonium, calcium, iron, and silver salts of it have been prepared, in whose formation it behaves as if it had the formula $C_{54}H_{48}O_{15}\,(COOH)_6$. Before drying, it dissolves in 625 parts of boiling water; but after drying, it requires 13,874 parts of boiling water to effect solution. It seems to be identical with ulmic acid.

Crenic and *apocrenic acids* are possibly oxidation products of humic acid. According to Mulder, crenic acid is $C_{12}H_{12}O_8$ and apocrenic acid $C_{24}H_{12}O_{12}$.

Wax is probably formed by algæ, and in appearance is a brownish-yellow solid, existing to the extent of 1 to 8 per cent. of the dry material of the turf. It probably consists of the higher monotomic alcohols with arachenic, behenic, and lignoceric acids.

Cellulose (woody fibre) $(C_6H_{10}O_5)_n$ is a colourless amorphous solid insoluble in water, but soluble in dilute acid on continued boiling, being converted into grape sugar.

Pentosane is an amorphous solid, which gives, on boiling with dilute acids, one or more sugars of the arabinose (pentose) series.

Tannine $(C_{14}H_{10}O_9)$, or gallotannic acid, is a colourless amorphous glancing mass readily soluble in water. When boiled with dilute acids, it is converted into gallic acid.

Resin is an amorphous solid which dissolves in alkalis, but is insoluble in water, and consists of mixtures of complicated bodies, such as abietic and pimaric acids.

Very few attempts have been made to determine the percentages of the substances above described in peat; and as the analyses are necessarily somewhat inexact, only one or two typical ones will be quoted here.

Wiegmann found that the dry substance of mountain turf contained:—

Humic acid, ...	27·6	per cent.
Wax, ...	6·2	„
Resin, ...	4·8	„
Earth resin, ...	9·0	„
Humic carbon, ...	45·2	„
Water, ...	5·3	„
Ash, ...	1·9	„
	100·0	„

Ferstl found that a sample of turf, which contained 14·5 per cent. water and 3.5. per cent. ash, contained :—

1. Matter soluble in water, 1·66 per cent., of which 1·5 per cent. was organic.
2. Matter insoluble in water, but soluble in hydrochloric acid, 3·07 per cent., of which 0·13 was organic.
3. Matter insoluble in water and acids, 82·31 per cent., of which 22·60 per cent. was humic acid, 34·70 per cent. was humic carbon, 4·10 per cent. was resin, 1·40 per cent. was wax, 16·22 was fibre.

According to Von Feilitzen, the amounts of cellulose and pentosanes in peat decrease rapidly with the depth of the layer in the bog. Thus the light surface turf from Speckener Bog contained 15·03 per cent. of cellulose and 12·75 per cent. of pentosanes; while the turf in the same bog, taken at a depth of about one foot, contained only about 6·64 per cent. of cellulose and 5·87 per cent. of pentosanes.

In a paper on the occurrence of Dopplerite in an Irish bog (Proc. Royal Dublin Soc., vol. x., 1903, p. 99), Mr. R. J. Moss, assuming Mayer's formula for monobasic humic acid ($C_{17}H_{18}O_{8}$), found 72·87 per cent. of humic acid in the Dopplerite and 39·98 per cent. of humic acid in the adjacent peat.

12. *Drainage of Irish Bogs.*

As peat deposits vary much in character owing to differences in age, nature of flora from which they have been formed, and percentages of ash, it will, as a rule, be necessary to make a preliminary examination of a bog before deciding on the most suitable plan for its utilization.

The next important step will be the provision of a system of drains controlled by sluices in the main drain or canal, which should pass through the centre of the bog, and have its exit at the lowest point. Numerous smaller side-drains branching at right angles to the main drain are, with the assistance of catch-water drains, sufficient to maintain the bog in a condition allowing of its cultivation on the one hand, or utilization for the manufacture of peat moss litter or peat fuel on the other.

Artificial drainage by water-spirals or similar machines is rarely required, and so far as I know is not necessary in this country; at least in the case of the larger flat bogs, for which an elaborate system of drainage was proposed many years ago.

The Reports of the Commissioners on Irish Bogs (1809–1814) contain detailed schemes for the drainage of the larger bogs in this country drawn up by various engineers, who were unanimously of opinion that the bogs of Ireland could be drained in an efficient manner without deepening the channel of any main river, and who gave in their reports detailed descriptions for each bog of the way in which this drainage can be effected. The engineers differ as to the methods of construction, and the depths of the required drains.

Mr. Edgeworth recommended small drains five feet wide, three feet deep, with perpendicular sides, and having numerous smaller surface drains eighteen inches deep between them.

Sir Richard Griffith, on the other hand, considered that deeper drains, with sloping walls, would be more suitable for the bogs surveyed by him. In his system of drainage the surface of the bog is divided into patches of about three and one-third acres each by means of:

(*a*) Main drains, 12 feet deep, 14 feet wide at surface, 2 feet wide at base.
(*b*) Minor drains, 8 feet deep, 9 feet wide at surface, 1 foot wide at base.
(*c*) Intermediate drains, 5 feet deep, 6 feet wide at surface, 1 foot wide at base.
(*d*) Cross drains, 5 feet deep, 6 feet wide at surface, 1 foot wide at base.
(*e*) Surface drains, 3 feet deep, 4 feet wide at surface, 1 foot wide at base.

He found that although drains with perpendicular walls stand well in a firm bog, they are not suitable for the flat red bogs commonly found in this country.

It was also pointed out by Griffith that in draining a bog two facts should be borne in mind. The first is that for the maintenance of a given area of bog in a dry condition, catch-water drains, which prevent the flow of water from the wetter portions into the drained area, are indispensable; and the second is that in the sinking of the drains due provision should be made for the subsidence of the bog as the water passes out of the peat.

Mr. Jones proposed for the drainage of the bogs surveyed by him a system similar to that of Griffith, and anticipated the probability of the main drains being afterwards used as canals for the conveyance of manure.

Mr. Townshend's drainage system was connected more intimately with the employment of the main and minor drains as canals than any of the other systems. The main drains recommended by Townshend were to be 29 feet wide at the surface, 14 feet wide at the bottom, and of such a depth (about 10 feet) as to give a permanent depth of water of 5 feet. The minor drains, which were to have a similar depth of water, he proposed to make 22 feet wide at the surface, and 7 feet wide at the bottom, so that they could be used as canals. Locks, sluices, reservoirs, and the other requisites of a canal system, were recommended.

The plan of drainage finally adopted by the Commissioners comprised main, minor, and surface drains, with a recommendation that when the system had been established provision should be made for internal traffic, either by the navigation of flat-bottomed boats on the main drains, or by the carriages on portable railways invented by Edgeworth.

13. *Utilization of Surface of Bog.*

The surface of the bog which is not immediately required for the manufacture of turf products can be planted with shrubs or trees, such as Scotch fir, birch, alder, and larch, provided the bog has been subjected to a slight preliminary preparation by draining and surface-ploughing.

Many acres of Irish bogs have been planted in this manner as early as the middle of the eighteenth century—one of the first of such plantations being that of some bogs on Lord Charleville's demesne, the trees of which were found in a healthy state in the year 1811. Sir Richard Griffith described in the Bog Reports healthy trees which he inspected, in 1813, at Woodlawn, and which had been planted on the surface of a bog in 1758. As a rule, trees with long tap-roots do not grow well on peaty soil; but those which send out horizontal roots in the manner shown in Pl. XXXVI., fig. 1, thrive almost as well on prepared peaty as on ordinary soil.[1]

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[1] From Reports of the Bog Commission.

Similarly, the bog can be planted with various fruit trees. Raspberries, blackberries, and cranberries grow well over the surface, and gooseberries or currants round the edges of the bog. The fruit of these plants not immediately required for consumption can be converted into jam or wine. A shallow bog, whose depth does not exceed five feet, resting on a sandy base, can be advantageously cultivated by a method introduced by Rimpau. The bog is drained by trenches sunk to a depth of about three feet, and peat ridges are made round the parts to be cultivated, whose surface is then covered to a depth of four inches with sand, dug from the trenches. Farmyard or artificial manure, consisting of kainite and Thomas' phosphate meal, is added, and on the prepared surfaces oats, beans, rape, or potatoes can be raised. At Cunrau, where this method of cultivation was employed, the owner of the bog, with an initial cost of £6 per acre, had for a period of ten years an average annual net gain of £1 16*s.* per acre. The method is, however, obviously not applicable to all bogs. High or mountain bogs are, perhaps, best cultivated by digging trenches through them thirty feet apart. The surface is then levelled, harrowed, limed thoroughly, and after manuring with kainite, and Thomas' phosphate meal, Chili saltpetre, or ammonium sulphate, remunerative crops of potatoes and oats can be produced.

Some years ago in Germany the commonest method for cultivating bogs was by manuring the surface with turf ashes. For this purpose the bog was thoroughly drained, and its surface harrowed. It was again harrowed in April and early May until the peat mould was sufficiently dry to be ignited. The ashes got by burning the ridges of dry peat were distributed over the surface, which was then planted with buck-wheat. The surface of the bog could be burned about three times, and must then be left fallow for upwards of thirty years before it can be re-burned. The method was, therefore, inconvenient; depended too much on the state of the weather at the close of spring, or the beginning of summer, and gave rise to so much disagreeable smoke in the peat districts of Germany that it is no longer encouraged by the Government.

A better method is that generally employed in Holland, and known as the *Dutch Fen Reclamation Process*, which has been in operation in Holland for the past two hundred and seventy years. A main canal, 36 feet wide at the water-level, 22 feet wide at the base, and 5 feet deep, with locks about 70 feet in length, is cut by the State or Province through a suitably shallow bog resting on a sandy soil. Arrangements are made so that during dry summers the higher portions of the canal can have a sufficient water-depth maintained by the back-pumping of the water from the lower.

From each side of the main canal narrower parallel side-drains run out for a considerable distance, at right angles to it. On each of the intervening strips between the parallel side-drains two colonists are placed, each of whom is responsible for the cultivation of a side of the strip.

Briefly, the method of cultivation adopted consists of:—

(*a*) Removal of the upper stratum of light turf, which is placed on one side.

(*b*) Cutting, saving, and disposal of the underlying fuel turf down to the sandy base.

(*c*) Mixing of the upper layer of light turf with the sandy base of bog, and, after addition of manure, the cultivation of crops in the ordinary manner.

According to Birnbaum ("Die Torf-Industrie," p. 147), this system was first used in 1633 at Emden, in East Frisia, and at Groningen, in Holland.

Probably the earliest writer on the improvement of Irish bogs was Dr. Gerard Boate, a Dutch physician, who resided in London. About 1644 Dr. Boate bought some forfeited lands in the provinces of Leinster and Ulster, and, with a view to improve the acquired property, collected much valuable information on the industrial resources of Ireland from his brother, Dr. Arnold Boate, another physician, who lived in Dublin for some time, and several Anglo-Irish gentlemen, such as Sir William and Sir Richard Parsons. Dr. Gerard Boate, on his appointment as Doctor of Physic to the State in Ireland in 1649, visited Dublin, but died shortly after his arrival. In 1652, two years after his death, a work written by him in 1645 was published under the title, "The Natural History of Ireland."

Dr. Boate divided the bogs of Ireland into four classes—(*a*) Grassy; (*b*) Watery; (*c*) Muddy; (*d*) Hassocky; and ascribed their origin to the superabundant water allowed to collect owing to the neglect of drainage by the Irish, which produced, as he says, "rotteness and spunginess."

Even at that date (1645) a fairly exact theory as to the origin of bogs seems to have been elaborated.

He further describes the methods of draining bogs at that time adopted in Ireland, in the following words:—"On that side of the bog where the ground was somewhat sloping, they cut a broad, deep trench, beginning it in the firm ground and advancing it unto the entrance of the bog, into which trench the water would sink out of the next part of the bog in great abundance. . . . Some part of the bog being by this means grown reasonable dry within a short space of time, opportunity thereby was ministered to advance the trench further into the bog; and so by little and little they went on with it untill at last they carryed it quite across the bog from one side to the other; and having done this they made a great many lesser trenches out of the main one on both sides of the same; the which bringing the water from all parts of the bog unto the main trench, did in a little while empty the bog of all its superfluous moysture, and turn it unto good and firm ground."

Several Anglo-Irishmen informed Dr. Boate that they had drained hundreds of acres of bogs in this manner, and converted them after addition of manure into good land. Unfortunately in this connexion he does not specify the nature of the manure employed, but elsewhere in his work he describes the properties of lime, dung, ashes, marl, and sand as manures, and evidently the method employed in Ireland for the reclamation of bogs in 1644 was similar to the Dutch Fen method above described, but differed from it in the absence of colonization and the non-removal of the fuel turf.

Later on, in the reign of King William III., the Dutch offered ("Philosophical Survey of South of Ireland," p. 126), upon condition of being governed by their own laws, to form a colony in the Queen's County, and to make meadow of the Bog of Allen.

The necessity for reclaiming the bogs of Ireland was regarded as so vital by our ancestors that we find them recommending so long ago as 1660 (Philosophical Transactions, "Lowthorpe's Abridgments," p. 732) that "An Act of Parliament should be made that they who did not at such a time make some progress in draining their bogs should part with them to others that would." About sixty-five years later a Bill was actually passed by the Irish Parliament for the Encouragement of Tillage, the Drainage of Bogs, and for Inland Navigation, whose promoters do not, however, seem to have adopted the drastic remedy of the earlier writer, although a similar law enforced in Germany during the reign of Frederick the Great (1765) was more in the line suggested above.

The method recommended by Sir Richard Griffith for the reclamation of bogs, which is given in the Reports of the Commission on Irish Bogs (1809–1814), was:—

1. Drain the bogs, and let them lie for about two years until the surface has subsided.
2. Make roads on the edges of the bogs for the conveyance of manure.
3. Spread about 350 tons of gravel per acre over the surface, which is then ploughed lightly and manured with lime or ashes.
4. The prepared surface is then subjected to a four years' rotation of crops as follows:—(*a*) Rape; (*b*) Potatoes; (*c*) Oats and Hay-seed; (*d*) Meadow.

The total cost of improvement and cultivation during the four years was estimated at £44 13*s.* 4*d.* per acre, and the value of the crops produced in the same time at £55 14*s.* per acre.

After deducting 10 per cent. from the estimated value of the crops, and adding 10 per cent. to the probable outlay, Sir Richard Griffith believed that by an expenditure of £2 12*s.* 1*d.* per acre for drainage and cultivation the reclaimed land would have at the end of the four years a letting value of £1 10*s.* per acre. Abundance of sand is as a rule found in the immediate vicinity of the bogs in the great central plain of Ireland, so that as far as that is concerned the expense of sanding the surfaces of the bogs would not be abnormally high.

Many instances are given in the Reports of the Bog Commissioners of the successful reclamation of Irish bogs in the eighteenth century by sanding or burning the surface according to the locality, one of the earliest being that of a portion of the Kenmare River Bog in 1753 by Mr. Bland. In 1770 thousands of acres belonging to the Marquis of Sligo, in the neighbourhood of Westport, were reclaimed by a system of catch-water drainage, ploughing, burning, and liming the surface.

At the beginning of the nineteenth century Edgeworth made a careful estimate of the cost of reclaiming a small portion of a bog by draining it, and manuring the surface with lime, limestone, gravel, and marl. After working 27 acres of bogs in this way during a period of five years, and keeping an accurate account of all expenses incurred, he found that there was a clear profit of £17 on the plot, and that the surface had been so much improved that he was able to let the plot at 30*s*. per acre to a farmer who had previously refused to take it at 10*s*. 6*d*. per acre.

About the same period a bog of 343 acres on Lord Digby's estate was reclaimed by draining, levelling, and burning, with an increase in letting value of from 5*s*. to 35*s*. per acre. As an example of the gradual but continuous reclamation of Irish bogs which has been going on for the past 300 years, one of the engineers engaged in the Bog Survey states that of the 1173 acres of bog present at Bunnahindley at the date (1655) of the Down Survey, about one-half had been reclaimed between that time and the year 1811, when it was resurveyed.

14. *Peat as Manure.*

Bog-stuff as manure for land was known and used in Ireland towards the earlier half of the seventeenth century. In Dr. Boate's work on the Natural History of Ireland the author states:—

"And I know severall other English who, living in Ireland, did use to take the scouring of their ditches together with other mud digged out of the bogs, and, having let it lye a good while a rotting in great heaps, did afterwards carry it upon their lands in lieu of dung; the which they found good and usefull for that purpose."

In the middle of the nineteenth century considerable quantities of turf charcoal, manufactured at Derrymullen, were sold to farmers for use as manure.

The best form of peat for this purpose is that of the waste peat-moss litter from stalls in which it has become saturated with liquid manure; but as this substance will be treated of fully under the heading "Peat-Moss Litter," it need not be further considered here.

15. *Utilization of Water in Bog Canals.*

The water-power of the main canals can be used to drive turbines, whose motion can be converted into electrical energy, and stored in accumulators for subsequent employment in driving machinery.

In the water reservoirs the artificial rearing of fish has been attempted with some success. Experiments made with pike, carp, and trout on the Continent have shown that from each acre of canal water properly stocked with fish a net annual gain of £10 should be realized.

16. *Utilization of Cut-away Bog.*

The surface of the bog from which the peat has been removed can also in most cases be cultivated. The dried peaty refuse is collected and burned in heaps. The ashes are distributed over the surface, mixed with sand to counteract the heaviness of the loam, lime and bone meal added, and the whole thoroughly incorporated. On the prepared soil potatoes, turnips, and cereals grow well. If the surface of the dug-out bog is very uneven, as often happens in the case of a mountain bog, its cultivation will not be remunerative.

Where a heavy clay forms the base of the bog a brick-making industry can be established. The turf from the adjacent bog can be used as fuel, and its fibre forms an excellent substitute for the straw required in the industry. Assuming that one-third of the clay is available for the manufacture of bricks, it has been estimated that there would be a yearly profit of about 50 per cent. on the capital expended.

SECTION II.—PEAT-FIBRE INDUSTRIES.

1. *Percentage of Fibre in Peat.*

If we regard peat as consisting of the two parts—mould and fibre—it will be of importance before deciding on the most economical method for the utilization of a peat deposit that an exact knowledge of the relative amounts of each present should have been attained. As a general rule it may be assumed that the older the bog, and for the same bog the deeper the layer from which the peat has been obtained, the less the amount of fibre. According to experiments of Von Feilitzen ("Inaugural Dissertation," p. 27: Göttingen, 1897), peat moss (*Sphagnum cuspidatum*) contains about 21 per cent. of cellulose, light undecomposed surface turf about 15 per cent., and medium brown turf at a depth of 3–6 feet about 7 per cent.

2. *Utilization of Peat Fibre.*

The fibrous matter of peat may be employed in various ways, of which the following are the most important:—

1. Peat-moss litter.
2. Peat litter.
3. Peat paper.
4. Peat wool for clothes, carpets, antiseptic bandages, &c.
5. Roofing material for houses.
6. Insulating material for ice.
7. Preservation of fruit, vegetables, and manures (such as kainite); and packing of eggs, fish, flesh, &c.
8. Filtration of oils.
9. Manufacture of peat-molassine meal.
10. Preparation of alcohol by fermentation of the previously hydrolysed cellulose.

3. *Peat Litter.*

Any variety of peat which contains a sufficient percentage of fibre can be converted into peat litter; but the value of the substance thus produced will vary greatly with the nature of the plants from which the peat had been formed. As already mentioned, the mountain bogs are generally formed by the decomposition of the peat mosses (Sphagnum) and the wool grasses (Eriophorum); and as these plants are characterized by their great absorptive power for water, the most valuable sort of peat litter is, as a rule, got from mountain bogs (peat-moss litter). Flat bogs in this country are mainly used for the manufacture of peat litter. When the peat litter obtained from them is that formed from grass peat, it is not so valuable as peat moss litter. Moss-peat is of a yellow colour, sometimes slightly tinged with brown, very light, and contains a low percentage of ash, and a relatively high amount of undecomposed particles of the original plants. Grass-peat, on the other hand, is of a darker colour, heavier, more decomposed, contains a larger percentage of ash, and has a lower absorptive power for water.

The best peat moss districts in Ireland are said to be round the southern shore of Lough Neagh in the north, and in the King's and Queen's Counties in the Midlands.

4. *Manufacture of Peat-Moss Litter.*

Large sods of peat, containing about one cubic foot each, are dug out of the bog, dried in the air, and then, to prevent reabsorption of water by them, stored under cover. If cut during the winter, care should be taken to leave a layer of peat moss over the underlying peat fuel of sufficient thickness to prevent the injury of the latter by frost.

The air-dried turf is next placed in the upper funnel-shaped mouth of a dividing machine (so-called wolf) (figs. 2 and 3), in whose body the peat is torn to pieces by rotating circular saws, and from which it is delivered in a divided state either on to a sieve or an elevator.

A form of divider (fig. 2) with a large mouth-piece, capable of receiving several sods simultaneously and well suited for the bigger peat-moss litter factories, has been recently constructed by Dolberg, of Rostock. It is said to run smoothly, without causing appreciable vibration in the building.

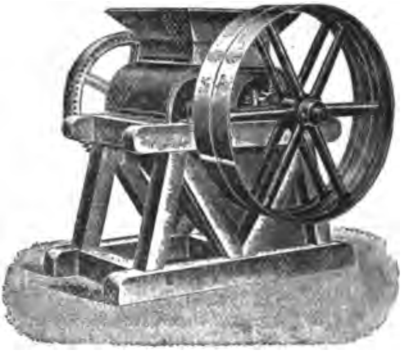


Fig. 2.

The machine is made in three sizes, the largest of which can turn out thirty-five tons of peat-moss litter per day. A smaller machine, driven by hand, can make about five tons per day.

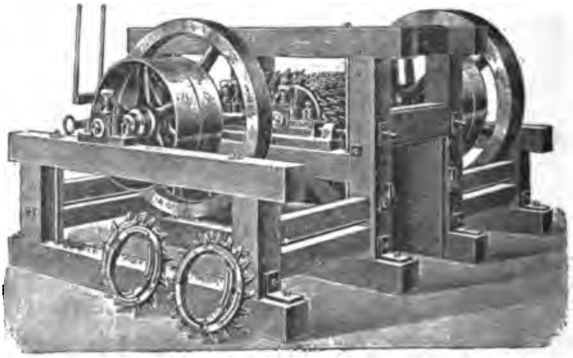


Fig. 3.

Of the many dividing-machines made by Heinen, of Varel, that which is best suited for a large factory is the double divider R4 (fig. 3).

Owing to the ease with which the circular toothed rings can be separately removed from the machine, the dividing-apparatus is easily sharpened and repaired when necessary. The daily output of peat-moss litter from this machine is about forty tons.

5. *Turf-mould Mills.*

Occasionally it may be necessary, owing to the increasing demand for turf-mould in the fruit-packing and similar industries, to supplement the amount of mould separated from the divided peat by the sieves, to be hereafter described, by direct preparation from the dried peat; and for this purpose many turf mills have been constructed, of which I shall describe two in this paper.

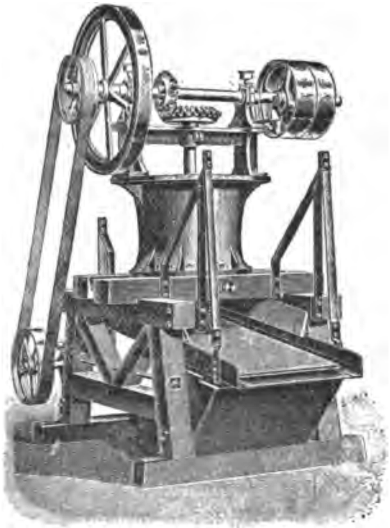


Fig. 4.

Heinen's turf-mould mill (fig. 4) consists of a body in which the turf is finely divided by a vertical rotating crusher, and is then passed on to a shaking sieve supported on a stout wooden frame.

The largest size can, when driven by a ten-horse-power engine, turn out seven and a half tons fine turf-mould per day.

The new turf-mould "divider" of Dolberg (fig. 5) has two drums—the one a slowly rotating "feeder," the other a rapidly rotating divider.

The very finely divided peat is passed through a shaking sieve supported by the frame-work of the machine.

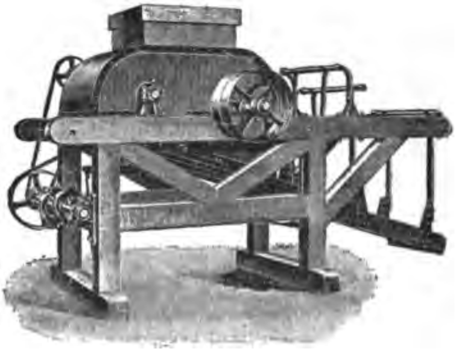


Fig. 5.

The larger size divider has, when driven by a 21 E. H.P. engine, an estimated daily output of from twenty to twenty-five tons of turf-mould.

6. *Sifting the Divided Peat.*

The sifting of the divided peat can be carried out in either flat or cylindrical sieves, each of which has its advantages and disadvantages.

The flat sieve (figs. 4 and 5), which otherwise is a convenient form, may cause such continuous and serious vibrations as to endanger the stability of the building.

This can, however, to a great extent be obviated, either by placing them on the ground-floor, or by employing, instead of them, the other form—cylindrical sieves. In fig. 8 a cylindrical sieve (*S*) is shown in position. This form causes little vibration, and can, therefore, be placed in that portion of the building which may be considered most convenient. The cylindrical sieve, on the other hand, has the disadvantage of becoming readily stopped by moist mould.

7. *Baling the Divided Peat.*

The dry divided and sifted peat is still in a condition very little suited for transport.

The customary form in which the peat-moss litter is sent into the market is that of the "bale."

In small factories the "baler," employed for compressing the litter, is one that can be worked by hand (fig. 6).

The peat litter is placed in a box-shaped compartment, whose base consists of a movable floor on which three wooden laths are laid, until the space is completely filled with the litter. After placing three more laths on the top, the cover is tightly clamped and the litter compressed slowly by two men working the levers shown in the figure. When fully compressed, the side-walls are opened, the bale tied with wires, the piston-floor lowered somewhat, and the bale removed. More convenient for a large factory is a large knee-lever press, such as that used at the Peat-Moss Litter Works in Umaras, which I shall now describe.

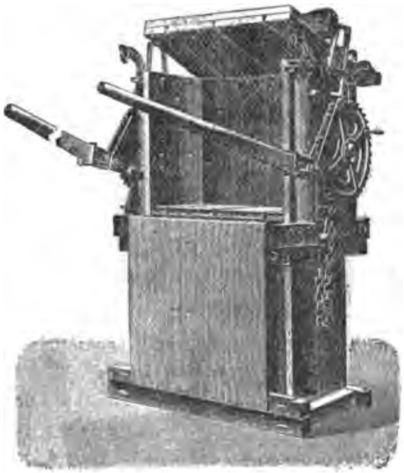


FIG. 6.

The "baler" or press used in the Peat-Moss Litter Works, which are situated near Monasterevan, is shown in the annexed photograph (Pl. XXXVI., fig. 2). Two or three laths are placed on the movable bottom of the baler, and the divided peat passed into the body through the funnel at the top, the sides having been previously closed and clamped. When full, three laths are placed on the top, which is closed, and power applied from below by levers raises the movable bottom until the peat is thoroughly compressed. The sides are then opened, and wires passed round the laths are tied firmly. On slightly lowering the bottom the tied bale of peat litter can be shoved out. About eight minutes suffice for the making of each bale. Another form of baler, which need not be set upon such solid foundations as the vertical baler, is the *horizontal* or *spindle lever* baler, which can also be worked by an engine, and usually gives a somewhat larger daily output than the corresponding vertical baler can under similar conditions.

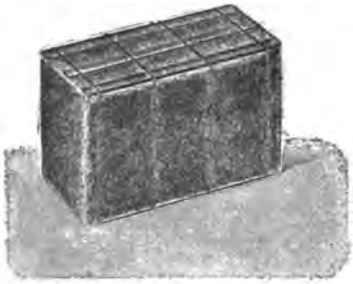


Fig. 7.

8. *Peat-Litter Bales.*

A bale (fig. 7) is generally about four feet long, two feet nine inches broad, and two feet high. It has a volume of about twenty-one cubic feet, and a weight of approximately three hundred to four hundred pounds. Four cubic feet of peat fibre give from one to two cubic feet of compressed peat litter. At Schussenried the cost of production of peat litter is fifteen shillings per ton; at Gratzen, in Bohemia, it is said to cost twenty shillings per ton; and in both countries the price obtainable for it, which varies with the scarcity or abundance of straw, from year to year, is on the average twenty-five shillings per ton. These estimates are, however, considerably higher than those which will be given later on.

One hundred tons of air-dried moss turf gives on the average sixty-three tons of peat-moss litter, and twenty-five tons of turf-mould, there being usually a loss of about twelve per cent. during the various stages of the manufacture.

9. *Peat-Litter for Farmers.*

In some countries the farmers in the immediate neighbourhood of bogs prepare a quantity of peat-litter for use on their own farms by the simple process of ploughing and harrowing the surface of the bogs during fine weather. The air-dried turf is gathered into wind-rows, and the intervening bog strips again ploughed and harrowed. When a sufficient quantity of air-dried peat has been collected, it is made into a heap, and thatched to protect it from the weather until required for use. It is freed from dust by sifting before employing it in stalls as "bedding."

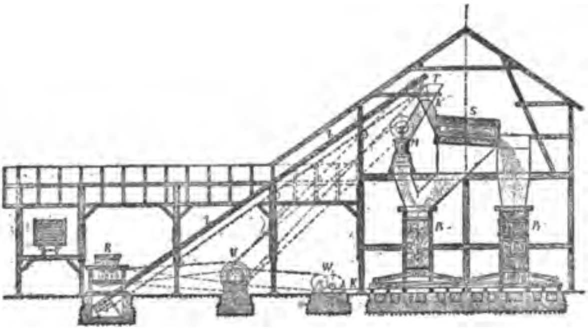


FIG. 8.

10. *General Plan and Cost of Peat-Moss Litter Factory.*

The arrangement of the various machines in a peat-moss litter factory, adopted by Heinen (Varel), Oldenburg, is shown in fig. 8.

The peat sods are delivered from a waggon on a slightly elevated platform into a dividing machine *R*, the disintegrated peat from which is carried by an elevator Z to a funnel T. From the latter it can be discharged without sifting, directly into a baler P_1, or if preferred it can be subjected to a thorough sifting in the cylindrical sieve S. The mould passes into P_1 and the fibre into P_2. In the latter way the baler P_1 is used for the pressing of turf-mould, and the baler P_2 for the sifted peat-moss litter.

The cost of production of peat-moss litter varies so greatly with the accessibility of the bog, its nature, extent, and many other circumstances which must be classed as local, that separate estimates must be made for each particular bog.

The following estimate, drawn up by Heinen, may be taken as applicable to many German factories with a daily output of 32 tons for 270 working days per year.

Cost of Plant:—

1. Buildings and sheds..	£400
2. Overseer's dwelling	150
3. Engine of 31–37 effective horse-power and accessories	375
4. One dividing machine, two balers, one elevator, one rotary sieve and accessories	450
5. Portable railway and other expenses ..	125
Total	£1,500
Working capital ..	750
	£2,250

Profit and Loss Account.

A. *Income.*

a. 6,480 tons peat-moss litter, at 13*s.* 6*d.* per ton	£4,374
b. 2,160 tons turf-mould, at 15*s.* per ton	1,620
Total	£5,994

B. *Expenses.*

a. 8,640 tons air-dried turf, at 6*s.* 11*d.* per ton		£2,981
b. Wages (14 men), at £2 0*s.* 3*d.* per day, with fuel, oil, wires, &c., at £3 2*s.* 0*d.* per day		1,380
c. Interest on capital, depreciation of plant, &c.		600
		£4,961
Gain on year's work ..	£1,033	
Other losses	33	
Net gain		£1,000

From the above estimate we see that, even at a selling price of 13*s.* 6*d.* per ton for peat-moss litter at the factory, there will be under favourable conditions a net dividend of about £71 per £100 of plant cost.

The estimate assumes the cost of production of peat-moss litter to be about 6*d.* a bale, or 2*s.* 9*d.* per ton, exclusive of the cost of the air-dried turf (6*s.* 11*d.* per ton). Including all the necessary expenses, Heinen estimates the cost of production of ten tons of peat-moss litter at £5 14*s.*, which estimate is, however, considerably lower than those given above.

11. *Peat-Moss Litter in Stalls.*

The employment of peat as litter in stalls is by no means new, but its industrial preparation on a large scale in a suitable form for transport is comparatively recent. The first of these factories was that erected in 1878, by W. Hollmann at Gifhorn, and from that year the introduction of peat-moss litter may be said to date. Amongst many difficulties which have had to be overcome in the development of the industry, was the belief that cattle would be injured, either by refusing to lie on the peat, or by eating it, and that the dung would have little value as a manure. The name "turf litter" was perhaps the greatest obstacle to its success in the earlier days; and it can scarcely be a coincidence that the industry rapidly developed after the introduction of the name peat-*moss litter.* A substance which is to be used as a litter in stalls must be capable of affording a pleasing, soft, elastic, dry bed for the cattle, whose health it must not injure, and whose excrements it must readily absorb. It must also be capable of conversion into manure. Horses and cattle when accustomed to peat-moss litter lie on it even more readily than on straw; and weight for weight the peat litter remains drier for a longer time than straw litter—its absorptive power for water being three or four times that of the latter. Not only are the liquid excrements more readily absorbed by the peat-moss litter than by straw, but the air of the stable is also kept much fresher by the absorption of the gaseous products of decomposition, such as ammonia. Nessler has shown, for example, that one pound of peat-moss litter will absorb eight times as much ammonia as one pound of good straw litter. In this way the peat keeps the stable atmosphere purer, and the manure is consequently richer in nitrogen. The space required to store the dung from a "peat-litter" stable is only half what is required to store that from a "straw-litter" stable per horse. With the addition of five per cent. of kainite the peat litter manure becomes more valuable for land than straw litter.

It has been used with advantage as litter for horses, cattle, pigs, and dogs, with or without a slight layer of straw on top of the peat. For long-wooled sheep it cannot, however, supply the place of straw. Although cattle in certain diseased conditions sometimes eat turf, which undoubtedly may give rise to serious digestive troubles, as a rule, the wide experience of numerous dairy farmers indicates that the injurious effects arising from this cause are practically negligible.

The beneficial effects attending the replacement of straw by peat litter in stalls, depend largely on the quality of the peat litter employed. The litter should be light, well divided, and free both from hard, earthy particles and dust. In appearance it should be mossy or grassy. The percentage of water in it should not be more than twenty-five, nor should its ash-percentage exceed five. The absorptive power of the litter for water, which should not be less than 800, will depend on the character of the peat from which it has been obtained, as well as on its method of manufacture (drying and division). Litter obtained from good peat moss may have an absorptive power of 2000, while in that got from grass peat, the absorption may easily be below 800.

12. *Testing Peat-Moss Litter.*

A rough examination of peat-moss litter may and ought to be made by every stall-owner who proposes to use large quantities of this substance. In the first place, the buyer should see that the weight of the bale received is the same as that consigned, as any decrease in the weight will indicate faulty pressing of the bale. Earthy particles may be found by stirring some of the peat litter in a glass vessel with water, and removing the floating fibres before they become saturated with the water, the earthy particles sinking to the bottom.

The most important determinations, however, are the absorptive power, water, and ash. The absorptive power is got by placing 10 ounces of the litter in water and letting it soak, after addition of a few drops of ammonia, when the litter is old, for one or two days in water. It is then filtered through a fine sieve, and when the water has ceased to drop the residue is weighed. The increase in weight multiplied by ten gives the absorptive power.

The percentage of water may be got by drying a weighed quantity of the litter at a steam heat for six hours; and by burning the residue in a weighed porcelain dish, the percentage of ash can be obtained.

13. *Irish Peat-Moss Litter Factories.*

The peat-moss litter factory at Umaras, near Monasterevan, which was started several years ago, is at present owned by the Standard Peat Fuel Company. About seventy persons are directly or indirectly employed by the Company, who manufacture peat-moss litter, turf-mould for packing, fire-igniters, and peat-fuel. The turf is brought from the adjacent bog in cars, on a railway, to the factory, in which are a dividing machine, three balers, and an elevator. The daily output is estimated at about 30 tons of peat-moss litter.

The Peat Products of Ireland Company, afterwards called the New Irish Peat Products Company, whose capital was £25,000, manufactured at Coolaney, County Sligo, for some years, peat-fuel, peat-moss litter, charcoal, and other substances. It was provided with a peat-moss litter plant, erected on a solid concrete foundation, with elevator, baling presses, and mill, capable of turning out a bale of 2½ cwt. every 2½ minutes.

The Irish Development Company at Maghery, County Tyrone, is also provided with the most modern machinery, and exports considerable quantities of peat-mould to other countries.

In the factories of Colonel Dopping near Ferbane, of Messrs. Connell & Company at Ringsend, and of Mr. David Sherlock at Rahan, peat-moss litter is manufactured. The factory belonging to the Irish Peat Industry at Inchicore was unfortunately destroyed by fire last year.

14. *Peat Paper.*

For the manufacture of the finer sorts of paper, the best material is undoubtedly waste rags. Owing to the enormous consumption of paper in recent years, the available supply of rags is, however, only sufficient to meet about one-third of the demand, and hence paper-manufacturers have been obliged to seek in various directions for rag substitutes. Fibrous materials, such as straw and wood, which can be easily bleached, have been largely used in this industry, in addition to other bodies, whose employment is by no means entirely advantageous to the quality of the paper.

The fact that many manufacturers were selling paper at a price which was less than the sum of the cost of the crude fibre, and that of its conversion into paper, led to an examination of a large number of paper samples, when it was found that to the paper occasionally upwards of 50 per cent. of earthy impurities, consisting of alumina, silica, and water, had been added. No doubt the addition of alumina in small quantities makes paper smoother and more opaque; but when this addition is carried to excess, the paper, becoming brittle and easily torn, must be regarded as adulterated.

Light surface turf, containing a considerable quantity of well-preserved fibre, can undoubtedly be converted into a good strong paper, and, with an economic method of manufacture, would have a value in this industry of about £4 per ton. The conversion, however, of turf into paper is much more troublesome than of wood pulp, owing to the difficulty of freeing the turf from deleterious substances like humic acid and sand, and the costly and imperfect methods used to bleach the fibre.

For these and other reasons it is questionable whether the manufacture of paper from peat can at present be carried on with commercial success.

Coarser forms of paper, such as brown wrapping-paper and paste-board, have been made on a large scale from turf fibre, with addition of about 15 per cent. of rags.

The percentage of rags required to be added to the pulp depends on the degree of impurity of the peat fibre, and usually is greater than that required for wood or straw pulp.

Amongst the many processes patented in recent years for the manufacture of peat paper may be mentioned those of Brin, Zschörner, and Kalmann.

Brin's Process.—The peat is mixed and washed well with water. It is next treated with a 2½ per cent. sodium hydrate solution in a large copper boiler, which is heated, with constant agitation, until the internal pressure is about five atmospheres. After remaining at this temperature until the soluble matter has been extracted from the fibre, the liquid is run off, and the fibre, after being washed with water, is bleached by means of hypochlorous acid. The pulp is then ready for conversion into paper.

Zschörner's Process.—The method of Zschörner is very similar to that of Brin. The washed turf fibre is extracted under pressure with a weak alkaline solution, again washed with water, and bleached with hypochlorite of calcium or sodium. The bleached fibre is washed once more with a still more dilute alkaline solution, and the pulp converted into white paper in the ordinary way.

Kalmann's Process.—The crude peat is well mixed and washed with water until free from mould. The fibres are separated, pressed, and again soaked in water. By repeating the process under increased pressure the fibre can be obtained, it is stated, in a state sufficiently pure for conversion into coarse brown paper.

15.—*Description of the Celbridge Peat Paper Factory.*

In February, 1903, the Callender Paper Company, with a nominal capital of £25,000, bought from Mr. W. M. Callender certain patents for the utilization of peat-moss for the manufacture of paper, with premises and machinery adapted to this end, at Celbridge, in the County of Kildare, for the sum of £15,000. The mills were taken on a lease for ninety-nine years at a rental of £125 per annum, which was to be increased to £175 per annum after the expiration of the first five years.

The peat was brought on cars from the bog, which is at a distance of several miles from Celbridge. On reaching the factory the crude peat was placed in a large spherical revolving digester (see Pl. XXXVII., fig. 1) in which it was subjected to the action of a solution of dilute alkali. The digester was rotated, and the fibre delivered into a car running on a small iron railway which conveyed it to the scarifying and beating machine, where it was converted into pulp.

After passing through some sand-traps, the unbleached pulp was delivered on to an endless band, which brought it between the revolving rollers of a paper-pressing machine (see Pl. XXXVIII.) weighing about 150 tons, and whose total length was about 100 feet.

The paper band which emerged from the press was glazed and polished by passing between the rollers of a vertical machine (Pl. XXXVII., fig. 2).

The paper was cut into the required sizes, and tied up in bundles by girls working in the factory. The principal motive-power of the machinery was the electricity generated in a dynamo which was driven by a 200-horse-power turbine, worked by water from the adjacent Liffey.

The brown wrapping-paper, sold by the company, contained about 66 per cent. of peat fibre, was of a strong texture and excellent quality. According to a letter published in a daily paper on April 29th, 1905, Mr. Callender stated that the Celbridge Factory turned out yearly more wrapping-paper than all the other paper-mills in Ireland combined; and that continuous employment was given there to from forty to sixty persons.

It was scarcely to be expected, for several reasons, that the Celbridge Factory could be commercially successful. Owing to the cheapness of wood and straw pulp, unless the peat is carefully selected, the expenses of purifying it will, as a rule, be too great to allow of the process being made remunerative. Pure peat-moss contains only about 21 per cent. of cellulose in the dry state, and even the best surface turf rarely contains more than 15 per cent. of cellulose when dried, or 1¼ per cent. in the undried state. It would be necessary, therefore, to perform the preliminary separation and purification of the peat fibre as near to the bog as possible, the air-dried material being then packed in bales, and forwarded to the factory. At Celbridge only about one-tenth of the turf, brought at considerable cost several miles from the bog, was of any practical utility in the paper industry. Moreover, the by-products obtainable under certain conditions from the waste material were not utilized.

In June, 1904, a winding-up order was made against the Company, but it was stayed upon an affidavit being made by Mr. Callender that fresh capital, to the amount of £7,135, was subscribed for, which would enable the company to buy new machinery, and by its means to increase the output from 10 to 40 tons of paper per week. Of this capital £3,835 was subscribed. In June, 1904, debentures for £4,000 were issued, and in July, 1905, a chartered accountant was appointed receiver for the debenture-holders, who afterwards borrowed a sum of £500 to carry on the business. A winding-up order was finally issued in December, 1905; and the accounts submitted showed liabilities to the extent of £7,407, with no available assets. Since that time no paper has been made at the factory.

Similar peat paper factories at Admont, in Austria, and Groningen, in Holland, have experienced a like fate.

16. *Building Materials from Peat.*

A hard building material resembling wood has been prepared by subjecting a mixture of 92 parts of crude wet peat and 8 of slaked lime to a pressure of 500 atmospheres. The product, which resists the action of water and fire, can be worked as easily as wood, and has been used for paving streets, courtyards, and floors, as well as for the manufacture of furniture.

A cheap and efficient roofing material has been made from turf impregnated with tar, by Lindenberg, in Stettin; it costs about 1*s.* 9*d.* per square yard, and can be maintained for many years without much expenditure of time or money.

17. *Brown Dye from Peat.*

The extraction of a brown dye from turf is closely connected with the manufacture of peat paper. The waste brown alkaline fluids, got in the manufacture of the paper, are concentrated to a small bulk, and then treated with an excess of acid. The precipitated dye is filtered and dried. When mixed with size and water, it can be used as a paint; and when white-lead and zinc-white are added to it, the mixture can be used as an oil-colour.

18. *Tanning Material from Peat.*

The reactions which occur during the formation of peat from plants are of such a nature as to leave the greater part of the tannine of the plants undecomposed. By suitable processes the tannine of the turf can be rendered available for the conversion of hides into leather.

Starck found that a thick mash, produced by mixing peat moss with a solution of alum and salt, can be used for tanning.

The best-known process for the preparation of tanning-liquid from turf is analogous to that used for its manufacture from brown coal.

The powdered turf is treated with nitric acid in cemented cisterns until a small portion of the product ceases to give brown fumes when boiled with an excess of nitric acid. The mash is then diluted with water, and heated by a current of steam for several hours. A solution of stannous chloride is added, and the boiling is prolonged until the dark colour of the solution has changed to a light brown, when the liquid is decanted from the precipitate, and can be used directly for tanning hides.

19. *Turf-Wool.*

If peat fibres are to be employed as a substitute for wool, they must be strong, flexible, elastic, and capable of being spun easily into a bleached fabric. Although there are immense quantities of plant fibres, which, when separated, purified, and bleached, make valuable spinning material, one would scarcely expect that the dead cells of peat, which have been exposed to processes of decay for hundreds of years, can still retain the required properties.

Undoubtedly, most specimens of peat are unfit for conversion into peat-wool. That which is best for this purpose is formed by the partial decomposition of the mosses (*Sphagnum cuspidatum*) or wool grasses (*Eriophorum*).

The loose, elastic, light-coloured, upper layer of many mountain-bogs, characterized by the readiness with which it absorbs water and gases, readily affords fibres suitable for the manufacture of turf-wool. Still better results are obtained with the layer of wool-grass peat which usually rests on the sand of mountain-bogs, under the layer of peat fuel. Deposits of wool-grass peat are found less frequently in low or flat bogs in the layer intermediate between the older and younger turf.

Many years ago attempts were made to convert the woolly hairs of *Eriophorum* into cloth without success. The principal difficulty is in the breaking up of the bundles of bast cells into separate fibres. In all plants the bast fibre bundle consists of long, thick-walled cells, pointed at both ends, filled with air, and not, as in the case of parenchymatous cells, with living protoplasm. The bast fibre bundles of the wool-grasses run regularly, partly under the epidermis of the upper and lower surfaces, and partly in the centre of the leaf. The firmness of their leaves is due to the fact that the bast fibre bundles run parallel to the surface. When the peat decomposes, the parenchymatous cells are converted into mould, the bast cells remaining largely undecomposed. The high absorptive power of well-prepared turf-wool is probably due to the fact that the bast cells, being united in bundles in the crude fibre, cannot be brought into such intimate contact with the fluid as the nearly individual cells of the treated fibre. Before discussing, however, the properties of turf-wool it is better to describe two or three of the methods which have been employed in its manufacture from crude peat.

Béraud's Process.—In this method the peat, which has been previously well washed, is broken up or scarified by a rotating drum, whose surface is covered with wire needles. Béraud recommended for the purification of the peat treatment with either dilute alkali or acid for several hours, but attached no importance to it. As a matter of fact, if the acid treatment recommended were exactly carried out, the greater portion of the fibre would be converted into grape-sugar. The turf-wool, which was named Béraudine, consisted of hard, stiff, brittle fibres, wanting in flexibility and nearly every property of woollen material. It could neither be bleached nor dyed, and was only of utility for the manufacture of a sort of wadding.

Geige's Process.—The process introduced by Geige, in 1898, gives much better results than those which were attained by Béraud.

The peat, taken direct from the bog to the factory, which must be in the immediate neighbourhood of the latter, is stirred for several hours in a bath of weak alkaline solution (2 to 4 per cent.) to remove the earthy matters, and humic acid substances. The fibrous material is separated, dried, and scarified. It is next heated for several hours to 56° C. with very dilute sulphuric acid (½ to 1 per cent.) to convert the starch into sugar, and the traces of glucose present in the washed fibre are removed, after mixing with water, by fermentation with yeast at a temperature of 30° C. The fibres are then washed with water, and the fatty matters contained in them are extracted under pressure by hot petroleum ether. The fibres are finally washed, boiled with dilute alkali to remove the tannic acid, bleached, and dried.

The turf-wool obtained by Geige's method consisted of soft, woolly, strong, flexible fibres, easily spun, bleached, and dyed. Above all, they have an absorptive power exceeding that of all other fibres, due to the fact that the cell-walls, unprotected by impervious cork layers, can be brought, practically, into complete contact with the liquid to be absorbed. In the various steps of the process the intercellular substance, which serves to bind the cells together in the crude fibre, is disintegrated, and the bast fibre bundles are thus broken up into individual fibres.

Owing to the air-spaces in the cells, the turf-wool is a bad conductor of heat, and fabrics made from it are cooler in summer and warmer in winter than those made from other wool-substitutes.

Turf-wool can be spun either alone or mixed with other materials. A mixture of 25 parts of turf-wool with 37½ of wool, and 37½ of artificial wool, can be spun to thread No. 16 (i.e., 16,000 metres per kilogramme). When the mixture contains 50 per cent. turf-wool, the fineness of the thread is No. 10, and with 75 per cent. turf-wool a coarse thread, No. 1½, is got. Thread intended for the manufacture of clothes can only contain about 20 per cent. of turf-wool, whilst that for felt, carpets, horse-covers, and bandages, may contain up to 75 per cent. of the turf-wool.

The factory started at Düsseldorf for the manufacture of turf-wool by Geige's process has recently been obliged to close. The method employed at the factory of the "German Turf-Wool Works," in Oldenburg, is somewhat similar to that of Geige. The freshly dug peat is beaten up with water, and the fibres removed from the mash by forks on an endless chain. They are then washed in large vats with water, removed, freed from water, boiled with dilute acid, washed, fermented, and dried. The fibres are then freed from dust in a cylindrical sieve, and after being broken up in a scarifying machine are ready for the spinning process.

The cost of production of one pound of turf-wool is from 2*d.* to 3*d.* It costs nearly the same per pound as hemp and flax, is slightly cheaper than cotton, and about twice as dear per pound as jute.

20. *Food Stuff from Turf Fibre.*

On account of the large percentage of ash and the considerable quantity of sand which may be present in dense turf, the latter can under no circumstances be utilized as a food-stuff. Light surface turf may, however, be so used, but its nutritive value is practically nil. It contains so little nitrogenous matter that, even if it were all assimilable, the nutritive value due to its nitrogen would be very slight. Little is known of the chemical composition of peat, and still less of its physiological action. When we have stated that it exercises an astringent effect on animals, and that the tannic acid and resin contained in it may delay or stop digestion, we have almost summarized the whole of our knowledge of the physiological properties of peat. For this reason we should be very careful before giving very large quantities of peat fibre mixed with other food-stuffs to valuable farm live-stock. There is, however, one case where the addition of peat to an otherwise useless food-stuff enables the latter to be utilized. A valuable food-stuff, molasses, contains so many volatile acids, and so large a proportion of potash salts, that its laxative action is so intense that it can be given in only small quantities at a time to cattle. By mixing the laxative molasses with the astringent peat much larger quantities of the former can be assimilated by cattle without causing any serious digestive trouble. The value of the mixture of good peat fibre with molasses, which has been named "molassine turf meal," as a food for cattle, has been examined during the past ten years by various observers in Germany. The results obtained in these and similar experiments which were tried in Scotland were uniformly favourable.

In December, 1905, Mr. Justice Warrington decided in a case initiated by the Molassine Company, who have been for the past five years manufacturing this food stuff, that the combination of peat-moss and molasses formed, from the evidence submitted to him, subject-matter for a patent.

21. *Preparation of Alcohol from Turf.*

The substance from which alcohol is obtained in commerce is starch. By the action of an enzyme, diastase, or hot dilute acid, the starch is converted into grape-sugar, which can be readily fermented by yeast to alcohol and carbon dioxide.

Another plant substance, cellulose, can be converted into grape-sugar by the action of hot dilute acids on it, and therefore may be utilized in the manufacture of alcohol. A dense form of cellulose, like that contained in wood, requires too prolonged a digestion with dilute sulphuric acid for conversion into grape-sugar to allow of the process being made commercially remunerative.

Light, mossy turf, which in the dry-ash free state contains about 18 per cent. of cellulose in the form of loose, peaty fibres can be converted into alcohol without much trouble.

The crude, undried, fibrous peat is mashed with water, and diluted sulphuric acid added until the strength of the acid is about 2½ per cent. The acidulated mash is then heated in a closed boiler or digester to a temperature of 120° C. for five hours. The cold saccharine solution is partially neutralized with quicklime, and afterwards the neutralization is completed with powdered chalk. The mixture is concentrated by evaporation of portion of the water, and then filtered.

Yeast is added to the cold filtrate, and the fermentation of the sugar is allowed to proceed to a finish at a temperature of 30° C. The spirit is separated from the alcoholic solution thus got by distillation. From 100 lb. of dry surface turf about 6 lb. of absolute alcohol were obtained. There are many disadvantages in the process which remain at present almost insurmountable obstacles to its commercial success.

In the first place, the percentage of the dry peat which can be converted into alcohol is rarely more than 12; and as the reaction must be carried out with very dilute acid, the sugar solution obtained is very dilute and must be concentrated. The strengthening of the "wort" cannot, however, be carried very far, as there are probably other substances present in it derived from the peat, which would, when sufficiently concentrated, retard or stop the fermentation of the sugar to alcohol. For these reasons the spirit is finally distilled from a very weak alcoholic solution. About one half of the total reducing sugar formed in the hydrolysis is arabinose—a non-fermentable sugar which can take no part in the formation of alcohol. The chief objection, however, is that the refuse material left after the fermentation is almost valueless, while, on the other hand, the refuse left in the potato spirit manufacture is a valuable feeding stuff, which, when utilized as such, more than compensates for the slightly greater cost of the production of the alcohol from potatoes.

In conclusion, I must express my indebtedness to Messrs. Heinen & Co., of Varel, Oldenburg, and Messrs. Dolberg & Co., of Rostock and London, for the drawings of their machines which illustrate this paper, and to the managers of the Irish Peat Factories, as well as to the Economic Geologist of the Department of Agriculture for Ireland, for facts included in the foregoing paper.

At the end of Part II., which will deal with the peat fuel and peat distillation industries, a bibliography of the subjects treated in the two parts will be given.

EXPLANATION OF PLATE XXXVI.

PLATE XXXVI.

Fig.

1. Section of Turf-Bank, showing three distinct growths of trees, with horizontal roots developed.

2. Baler employed at the Peat-Moss Litter Factory at Umaras, near Monasterevan.

1

2

EXPLANATION OF PLATE XXXVII.

PLATE XXXVII.

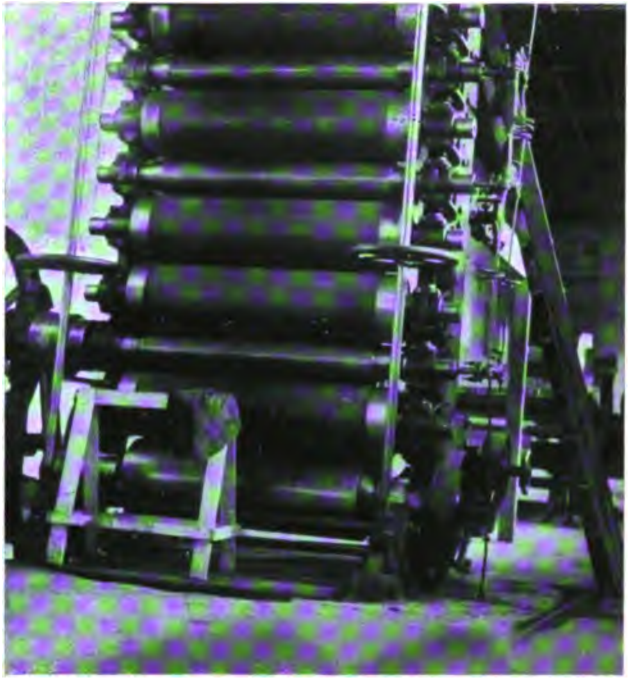
Fig.

1. Revolving-Digester, employed in the manufacture of peat paper at Celbridge, County Kildare.

2. Vertical Machine for glazing and polishing peat paper at Celbridge.

PLATE XXXVII.

1



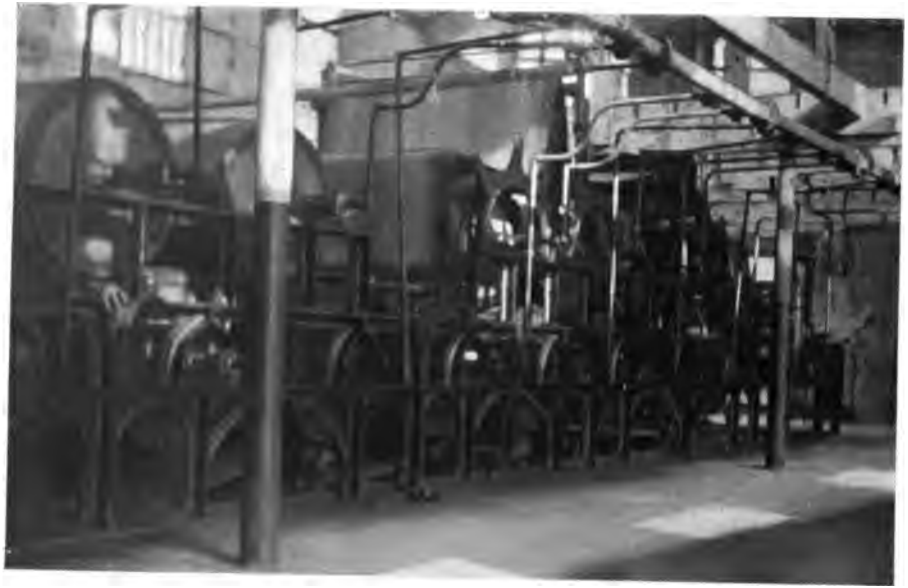
2

EXPLANATION OF PLATE XXXVIII.

PLATE XXXVIII.

Peat Paper Press, employed at Celbridge, County Kildare.

PLATE XXXVIII.



XIX.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1906.

By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Professor of Zoology in the Royal College of Science for Ireland, and Consulting Entomologist to the Royal Dublin Society.

(PLATES XXXIX.-XLIV.)

[Read, JUNE 18; Received for Publication, JUNE 21; Published, AUGUST 22, 1907.]

PARASITES OF DOMESTIC ANIMALS.

The Sheep-Louse.

Trichodectes sphærocephalus, Nitzsch.

IN January, 1906, wool infested with specimens of this parasite was received from sheep on Mr. John Borland's farm, at Angleboro' Mountain, near Mitchelstown. The flock had become contaminated by the straying in of undipped sheep from the neighbourhood; and though the lice appeared to be killed off by dipping, with an arsenic and whale-oil wash, in summer, autumn, and spring, they re-appeared in numbers the succeeding season, without any known contact with fresh sources of infestation.

These insects are not true sucking lice (Anoplura), but "biting lice" of the group Mallophaga, provided with stout toothed mandibles (fig. 1, B, *m*); by means of these jaws the insects bite their host's hairs and the surface and secretions of the skin, which serve as their food. Occasionally they draw blood from the host-animal. The legs are strong and stout (fig. 1, A, D), furnished in the family Philopteridæ, to which the present species belongs, with a single powerful claw, arranged so as to close against a blunt spine (fig. 1, D, *a*, *b*) on the foot, and thus to embrace a hair of the host, enabling the parasite to cling firmly. In the Philopteridæ, the mouth is situated beneath the head, and the second pair of maxillæ, united to form the "lower lip" or labium (fig. 1, B, *l*), are much reduced. The genus Trichodectes is easily recognized by the presence of only three segments in the feeler (fig. 1, A, B). In the present species the terminal segment of the feeler in the male is stouter and stronger than in the female, and bears several conspicuous sensory spines (fig. 1, B). The abdomen of the male (fig. 1, C) can be distinguished from that of the female (fig. 1, A) by the presence of a pair of conspicuous claspers, visible through the hinder segments. *T. sphærocephalus* is 1.5 mm. (about $\frac{1}{16}$ inch) in length.

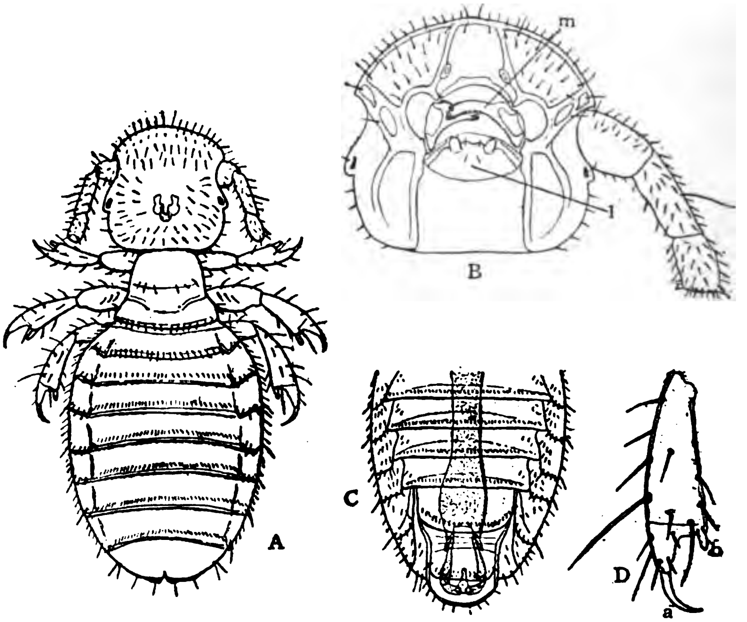


FIG. 1.—Biting Louse of the sheep (*Trichodectes sphærocephalus*, Nitzsch).

A. Female, dorsal view. Magnified 40 times.
B. Head of male, ventral view. Magnified 80 times. *m*, mandible; *l*, labium.
C. Abdomen of male, ventral view, showing claspers. Magnified 40 times.
D. Shin and foot of hind-leg. Magnified 80 times. (*a*) claw; (*b*) blunt spine against which claw works.

It is well known that the eggs of these parasites are attached to the hairs of the host, on whose body the whole life-history is normally carried on. It seemed likely, therefore, that the re-appearance of the insects some months after dipping was due to the resistance of the eggs to the effect of the dip. I recommended that on the next occasion a second dipping should be given about ten days after the first, as by that interval, the young lice would have probably been hatched from the eggs, and would thus be subjected to the poisonous action of the dip. From information kindly furnished by Mr. Borland in May, 1906, and again in January of the present year, I am able to record that this treatment proved altogether successful. Not a single louse had been observed on the sheep during the past twelve months. I am much indebted to Mr. Borland for permission to make these particulars known, in the hope that the facts may be of service to other flock-masters.

CORN INSECTS.

The Long-horned Barley-fly.

Elachyptera cornuta (Fallen).

In a previous paper of this series (4 (1905), pp. 282–5), reference was made to the presence of maggots of the well-known "Gout-fly" in barley. In August of the past year my attention was called to the experimental barley plots at the Albert Agricultural College, Glasnevin, under the care of Mr. H. Hunter, of the Department of Agriculture and Technical Instruction. A number of the plants showed swellings at the base, the enlargement being far less than that due to the presence of the Gout-fly maggot, and the plants being apparently able to "grow away" from the attack. Removal of the sheathing leaves revealed small brown puparia (fig. 2, *c*) close to the haulm, and a portion of the tissue where maggots had evidently been feeding was yellow and withered. Unfortunately no maggots could be found in the act of feeding; all had apparently entered the pupal stage. From the puparium it is evident that the tail-spiracles are situated on prominent paired processes. The puparia were, however, preserved, and late in September a number of flies emerged from them. These have been kindly identified for me by Mr. P. H. Grimshaw, of the Royal Scottish Museum, Edinburgh, as *Elachyptera cornuta* (Fallen).

This fly is included in the same sub-family (Chloropinæ) with the genera to which the Gout-fly (*Chlorops tæniopus* Meig.) and the Frit-fly (*Oscinis frit*, Linn.) respectively belong. Elachyptera may be distinguished from other genera of this group, by the relative shortness of the wings, by the extension of the costal nervure around the tip of the wing to meet the fourth longitudinal nervure, and by the thick, prominent "bristle" on the third segment of the feeler (fig. 2, *b*).

The present species, *E. cornuta* (fig. 2, *a*), is one of two species of the genus inhabiting our islands; the other, *E. brevipennis* (Meigen), has excessively short wings. Both were known as Irish insects to Haliday. *E. cornuta* is a small fly about 3 mm. ($\frac{1}{8}$ inch) in length, shining black in colour, with two rather broad, greyish stripes on the fore-body, and a shining brownish-black abdomen. The head is reddish yellow, with a rather large, black, triangular marking on the crown. The feelers are reddish-yellow, with their conspicuous "bristles" brownish-black. The legs are entirely yellow, except for the darker feet, and occasional median dark markings on the thighs and shins. (See Schiner, 14, ii., pp. 231–3).

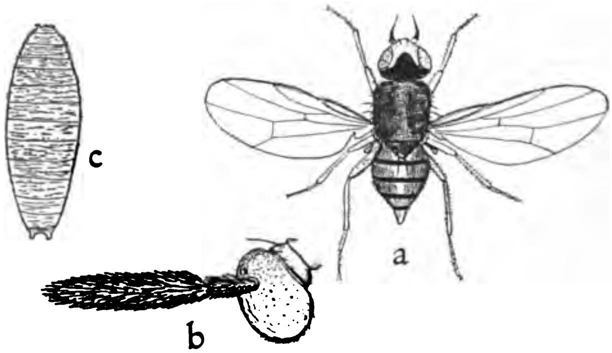


Fig. 2.—(*a*) *Elachyptera cornuta* (Fallen). Magnified 8 times. (*b*) feeler (side view. showing coarse, hairy "bristle." Magnified 60 times. (*c*) Puparium) Magnified 8 times.

It is probable that the autumn brood of flies which I succeeded in rearing would lay their eggs on wild grasses, as is the habit of the allied Gout-flies, and that the maggots from these eggs, after wintering, would become a spring-brood of flies to lay eggs on the young corn. The burning of refuse from an attacked crop with the contained puparia, which have been shown to rest within the sheathing leaves, would be, in any case, an obvious preventive measure.

CABBAGE AND TURNIP INSECTS.

The Diamond-back Moth.

Plutella cruciferarum, Zell.

The year 1901 was noteworthy for the prevalence of this insect in cabbage and turnip fields in our eastern Irish counties (4, pp. 144–7, figs. 16–21); but in that year no complaints of damage by the caterpillars were received from the west. It was of especial interest, therefore, to learn from Mr. J. Kelly, of the Department's Agricultural Station at Athenry, Co. Galway, that Swede turnips in that locality were suffering in July from the ravages of the caterpillars. Mr. Kelly kindly forwarded leaves for examination. In the same month I also received leaves eaten by these caterpillars from Mr. T. A. Rudd, Agricultural Instructor for West Co. Cork. It will be remembered that in 1905 (4, p. 326)[1] serious damage was done by these insects in Co. Wexford.

The Root-gall Weevil.

Ceuthorrhynchus pleurostigma, Marsh.

Turnips with the well-known characteristic sub-globular galls caused by the maggots of these weevils were received in February, 1906, from Mr. M. Horgan, Agricultural Instructor in County Westmeath. Mr. Horgan wrote that this malformation gives rise to numerous complaints, as "the affected roots never properly develop, and are subsequently liable to speedy decay, especially roots stored in large heaps."

Ceuthorrhynchus is a large and important genus of small weevils, of short, broad form, with slender, elongate snout, the

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[1] In the short paragraph relating to this insect (p. 326, *supra*), for "August, 1901," read "August, 1905."

funiculus of the feeler with seven segments, and the shoulders of the elytra incised. *C. pleurostigma* (more generally known as *C. sulcicollis*, Gyll) has the thighs with feeble teeth (fig. 3, 8), the legs and also the whole body dull-black in colour, with scanty greyish recumbent pubescence above, and a thick coating of whitish scales beneath, the thorax strongly constricted in front, coarsely, but not very closely punctured, with a strong central groove, and a small tubercle on either side. The length of the beetle is only 2 to 2½ mm. ($\frac{1}{10}$ inch, or less). In the male, the hind shin is armed with a hook, the hindmost abdominal segment is deeply and widely impressed, and the last segment but one has two small tubercles in front of the apex (Fowler, 8, v., p. 353).

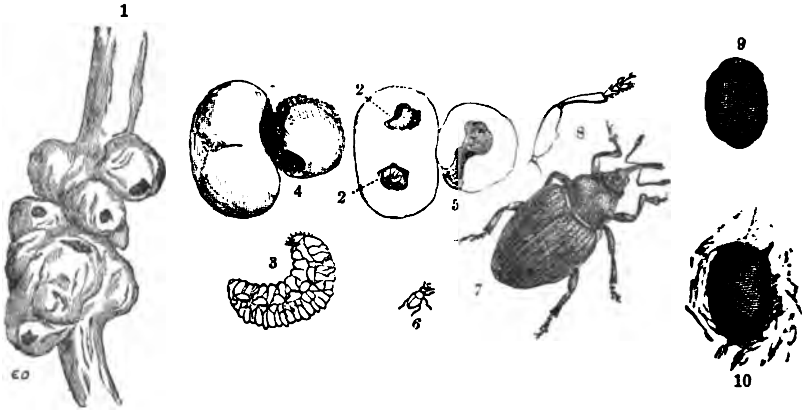

FIG. 3.—1, Galled Cabbage root, natural size; 6, Root-gall Weevil (*Ceuthorrhynchus pleurostigma*), natural size; 7, magnified 6 times; 8, foreleg, magnified 12 times; 4, external views of galls; 5, galls cut open, showing grubs (2) within, natural size; 3, grub, side view, magnified 4 times; 9, 10, earthen chambers of pupæ, magnified. From Ormerod, in part, after J. Curtis's "Farm Insects."

These beetles lay their eggs in spring or summer in the cabbage or turnip plants, and the presence of the grubs hatched from these eggs in the plant-tissues leads to the formation of the galls. The grub (fig. 3, 3) has a soft, whitish, wrinkled body without legs, and a hard, brown head furnished with strong mandibles. The grubs feed through the autumn, becoming fully grown in the winter or the succeeding spring, when they eat their way out of the galls, and pupate in oval earthen cases (fig. 3, 9, 10). Miss Ormerod (12 (1895), p. 17) records that they survive even if frozen stiff, "and on being thawed will at once bury themselves and begin constructing or reconstructing their cases."

No dressing can be applied with any confidence for the destruction of the grubs, on account of their protected feeding-places, though gas-lime has been recommended as effectual. The removal of galls with their contained insects when planting out young cabbages, and the destruction by burning of badly-damaged plants, are obvious preventive measures. So is a judicious rotation of crops, as these beetles feed only on cruciferous plants.

The Cabbage Stem-Borer.

Psylliodes chrysocephala (Linn.).

(Plates XXXIX., XL.)

Through my friend and former pupil, Brother Adolphus Ryan, I received in May, 1906, young cabbage plants from Limerick, with the root and stem-base bored by larvæ which clearly belonged to some Halticine beetle allied to the "Turnip Fly." In one of the plants it was clear that the insect had bored its way into the stem through a small hole (Plate XXXIX., B i) just beneath the surface of the ground. The presence of the grubs within the central tissue led to great discoloration and decay (Plate XXXIX., B ii). One of them pupated in an earthen chamber about 3 inches below the surface of some soil provided, and in three weeks' time this specimen developed into the common "flea beetle," *Psylliodes chrysocephala*. The genus Psylliodes is distinguished from the "Turnip flies" (Phyllotreta) and from most other Halticinæ by the presence of only ten (instead of eleven) segments to the feeler, and by the production of the hind shin into a process that reaches some distance beyond the insertion of the foot. Two species of Psylliodes are well known by their ravages in the perfect stage. These are the Hop Flea-Beetle, *P. attenuata* (Koch), and the Potato Flea-beetle, *P. affinis*, Payk. The latter of these has often attracted notice in Ireland (4 (1904), pp. 254–5; (1906), p. 329). *P. chrysocephala* (Plate XXXIX., A) is commonly taken by sweeping various cruciferous plants. It is about 4 mm. ($\frac{1}{6}$ inch) in length, of a metallic green colour, the front of the head, the three basal segments of the feelers, the thighs of the fore and median legs, and all the shins being yellowish. On the Continent this beetle is frequently destructive to Rape, devouring the leaves and flower-buds, according to Ritzema Bos (3, p. 367) and Kaltenbach (9, p. 29).

As it appeared that no larva of this genus had ever been carefully described, I published (5) an account with figures (Plate XL.) of the principal points in its external structure. From this account the following details are here reproduced:—

The fully-grown larva of *Psylliodes chrysocephala* is 8 mm. in length and narrowly sub-cylindrical in form (Plate XL., fig. 1). Excepting for the head, the pronotal shield, and the ninth abdominal tergum, the cuticle is soft and white. The three pairs of short thoracic legs and the "anal proleg" are present, as is usual in larvæ of this section of the Chrysomelidæ.

Head.—The form of the head and the arrangement of its bristles may be gathered from figs. 2, 4, and 5.[1] Except in the gular region, the head-capsule is strong and well chitinized. It is light-orange in colour, with dark chestnut-brown streaks arranged somewhat obliquely (fig. 5). As usual, the neighbourhood of the sutures is pale. There is a darkly pigmented patch on each side behind the feeler, but no ocelli can be distinguished; apparently the sense of sight has been lost in correlation with the burrowing habit of the larva.

The feeler is excessively reduced (fig. 3), consisting only of a short and wide basal segment and a sub-conical terminal segment. No trace of sensory structures can be seen on the latter, but the basal segment bears a short curved spine externally, and a prominent blunt spine with two smaller ones posteriorly.

The labrum (fig. 10) is light-yellow in colour, with longitudinal ridges and furrows on the distal part of its dorsal surface, on which four prominent bristles are situated. Its free edge is beset with four pairs of stout and a number of slender bristles, and a collection of tooth-like projections.

The mandible (fig. 11) is strong, with three prominent apical teeth, and a large globular condyle for articulation with the head capsule.

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[1] All the references to figures in this description are to Plate XL.

The first maxilla (fig. 12) is of the shape usual in larvæ of this family, the palp being feebly chitinized and imperfectly segmented, while the galea and the lacinia are not distinct from one another. The extremity of the lacinia carries several blunt, stout spines, and along the ridge which appears to represent the inner edge of the galea there are four long flexible bristles. The outer edge of the galea is strongly chitinized.

The second pair of maxillæ are intimately fused to form the labium (fig. 13), which consists of a broadly truncated triangular basal part, strongly chitinized externally, but white and membranous centrally, and carrying the feebly chitinized palps, each with a broad basal and a slender terminal segment.

Thorax.—The pronotum is firm and coriaceous in texture, pale in colour, and of somewhat wrinkled surface, with four series of dark impressed punctures arranged lengthwise (fig. 1). On the mesothorax and the metathorax there is a conspicuous darkish granular lateral patch carrying three strong bristles, and a smaller dorso-lateral patch with one bristle. The thoracic spiracles are situated ventro-laterally between the bases of the front and intermediate legs (fig. 1).

The legs (figs. 1, 8) are short and stout, showing only three distinct segments. A small sub-triangular, strongly chitinized thoracic sclerite overhangs the base of each leg, and the proximal segment of the leg is strengthened by a broad, arched, chitinized region, beset with a series of strong bristles. There is a similar but narrow sclerite at the base of the second segment. The terminal segment carries a strong claw, from the base of which projects a long setiform process, while internally to the claw is situated a large, wrinkled bladder-like tunica (fig. 9). It is impossible not to be struck with the similarity of this arrangement to what is found in the foot of a Collembolan of the genus Sminthurus.

Abdomen.—The first eight abdominal segments are all closely alike (figs. 1, 6, 7). The circular spiracle is situated laterally; ventral to it is a dark, granular patch with two bristles on either side, a smaller, similar patch with one bristle, and dorso-anteriorly to it another small patch with one bristle. Three transverse rows of simple bristles—2, 2, 4—are to be seen on the dorsal region of each of these segments.

The ninth abdominal segment (figs. 1, 6) has the tergum well chitinized, with straight lateral and rounded hinder margins, the central region being somewhat depressed and marked by longitudinal series of dark, impressed punctures. It is raised into two prominent hooked spines, which point upwards and inwards.

The only record known to me of this species as a destructive insect in the British Islands is that of Ormerod (13), who, in March, 1878, found the larvæ boring in the stems and "bulbs" of turnips in her Middlesex garden. The method of feeding in these turnips was apparently much the same as in the cabbages now under discussion, the tunnels commencing about the ground-level and running thence upwards into the stem or leaf-stalks, and downwards into the "bulb." No subsequent observation of the same kind in our own countries seems to have been made. But on the Continent these larvæ are well known through their serious ravages to the Rape crop. There, according to Ritzema Bos, who gives a full account of their habits (3, pp. 367–9), there is an early spring generation of beetles whose larvæ feed in the leaf-stalks of both winter and summer crops, from February till April, finally developing into a summer brood of beetles, which lay their eggs in autumn at the bases of the leaf-stalks of the young winter rape-plants. The larvæ hatched from these eggs bore their way into the stems and hibernate there, being able to endure the greatest cold; they finally develop into the spring brood of beetles. There is nothing in the life-history as observed by Ormerod and myself in England and Ireland respectively, inconsistent with the insect being also "double-brooded" here. Many insects, however, which have regularly two generations in the year on the Continent have usually one only in our islands.

MANGOLD INSECTS.

The Mangold Fly.

Pegomyia betæ (Curtis).

Leaves of mangolds, badly blistered by the maggots of this well-known fly, were received from Co. Cavan, in June. An account of this insect has recently been given in this series of papers (4, pp. 289–291, Plates XXIII.–XXIV.).

The Beet Carrion Beetle.

Silpha opaca, Linn.

Specimens of the black, woodlouse-like grubs of this beetle were sent, in June, by Mr. O. W. H. Roulston, who had received them from Rathdrum, Co. Wicklow; it was stated that they had "practically eaten out a mangold crop." The presence of this beetle as an injurious insect has been noticed rarely at rather long intervals in our islands. The earliest record—that of Curtis (7, pp. 388–393)—was from the North of Ireland, and it seems always to have been more prevalent here than in England. The occasional vegetable-ravaging habits of these insects are interesting and noteworthy, because the family Silphidæ are, as a whole, carrion feeders, certain species, however, preying on other insects, or on snails. The genus Silpha contains beetles that are flattened in shape, and more or less rotund in outline, the clubbed feelers having only nine segments. *S. opaca* may be distinguished from the other British and Irish species by its truncate pronotum, short head, deeply emarginate labrum (upper lip), and very distinctly clubbed feelers, the seventh antennal segment being markedly narrower than the eighth. It is a dull black beetle, 10 mm. (⅜-inch) long, and clothed with yellowish pubescence. (See Fowler, 8, iii., pp. 47, 50.)

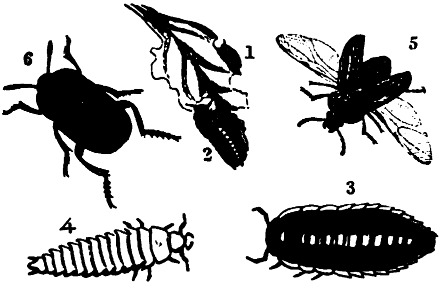

FIG. 4.—5, 6, Beet Carrion Beetle (*Silpha opaca*, Linn.) Magnified. 1, 2, larvæ on leaf, natural size. 3, 4, larvæ of Silpha, twice natural size. From Ormerod's "Reports," after Curtis.

The larvæ are flattened, hard-skinned insects with relatively elongate feelers on the head, a semi-circular prothorax, and the other trunk-segments with sharp, backwardly produced edges, the hindmost bearing a pair of short tail-processes (fig. 4, 3, 4). The form of the body, therefore, recalls strikingly that of a woodlouse, and these larvæ are very active. When they attack beet and mangold crops, they feed "mostly during the evening and early morning, when the leafage is moist, taking the young leaves first, and eating them down to the soil" (Ormerod, 12, 1895, p. 58). Later the grubs attack the root, gnawing it through just below the surface of the ground. When fully grown, they pupate in the soil, and after about three weeks' interval reappear as beetles. But few suggestions have been made for checking the ravages of these beetles. Ormerod (12, 1895, p. 59) recommended dusting the plants with a mixture of soot and lime while the dew is on the leaves, or entrapping the beetles and their grubs by placing putrid meat, dead birds, and similar objects about the infested fields, these carrion-traps to be, of course, subsequently collected and destroyed. The latter plan is stated by Theobald (15, i., p. 6) to prove effectual.

The Turnip Moth.

Agrotis segetum, Schiff.

Caterpillars of this common moth were received early in September from Stradbally, Queen's County. They had been feeding on mangolds in the same manner as they usually feed on turnips, and their presence led to blackening and putrefaction of the tops of the roots and the leaf-stalks. A similar attack by caterpillars of *Agrotis segetum* and the allied *A. exclamationis* on mangold has been recorded by Ormerod (12, 1893, pp. 54-60).

Agrotis segetum is one of the commonest of our Noctuidæ or Owl-moths. Moths of the genus Agrotis have long, narrow forewings, the thorax crested, the abdomen smooth, and the eyes not hairy. In *A. segetum* (fig. 5) the male insect has pectinated feelers, narrow, pale-brown forewings with dark orbicular and reniform markings ("stigmata"), and clear white hindwings; the female usually has uniformly blackish forewings and greyish hindwings, with dark-scaled nervures. The moth measures

38–40 mm. (about 1½ inch) across the outspread wings (Barrett, 1, iii., p. 288). These insects are on the wing in June, and the females lay their eggs on all kinds of low herbaceous plants. The caterpillars hide in the ground by day, and come out to feed at night; their common habit—as that of other agrotid larvæ—is to gnaw through the stems of young plants close to the surface of the ground, hence their farm-name of "surface caterpillars" or "cut-worms." Turnip and mangold "bulbs" afford food and shelter for a number of these destructive caterpillars. The great majority of the caterpillars of this moth live through the winter, feeding when the weather is mild, becoming torpid during periods of cold, and not attaining their full growth until the succeeding April; but a few individuals may feed up quickly, so as to pupate in August, and to develop into an autumn brood of moths.

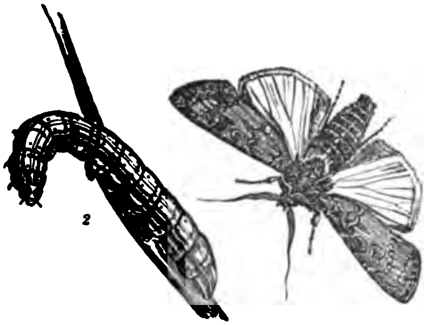

Fig. 5.—Turnip Moth (*Agrotis segetum*, Schiff.) 1, male; 2, caterpillar, natural size. From Ormerod's "Reports," after Curtis.

The caterpillar, when fully grown, is 36 mm. (1½ inch) in length, smooth and grey, sometimes with a pinkish or purplish tint; the head is light brown with two black or dark streaks; the longitudinal lines of the body are grey and indistinct; and the spiracles are black. In the allied *A. exclamationis* the spiracles are distinctly larger than the tubercles before and behind them. The pupa is reddish-brown, and rests beneath the surface in a small earthen chamber.

But little can be done directly for destroying these caterpillars on account of their concealed feeding habits. Turnips and mangolds badly attacked should be burned with the contained larvæ;

and it has lately been recommended by Theobald (15, i., p. 7, quoting a report of the Cornell Agricultural Experiment Station) to lay traps, consisting of bunches of clover previously poisoned by spraying with arsenical wash, about the fields, and so to compass the death of the insects. Their numbers are largely kept down by insectivorous birds.

CARROT AND POTATO INSECTS, &c.

The Carrot Fly.

Psila rosæ (Fab.).

Maggots of this fly feeding in carrots were received in July from Sligo. The insect has been fully described and figured in a recent paper of this series (4 (1904), pp. 255–7).

The Ghost Swift Moth.

Hepialus humuli (Linn.).

Complaints of damage to potato tubers by the caterpillars of this moth were received both in 1902 and in 1905 (4 (1903), pp. 195–7; (1906), p. 329). During the spring of 1906 these caterpillars were again received from potato fields near Naas, Co. Kildare.

The Spotted Millipede.

Blaniulus guttulatus (Bosc.).

Specimens of this small millipede were sent late in August from Killarney, where they had done great damage to potato crops. Reference to a similar attack by a Blaniulus in the year 1904 will be found in a previous paper (4, p. 295).

ORCHARD INSECTS.

The Winter Moth.

Cheimatobia brumata (Linn.).

The caterpillars of this moth were reported as injurious in apple orchards in Co. Clare and elsewhere in Ireland during the month of May. The insect has been somewhat fully described, and figured in the last of this series of papers (4, pp. 329–331, Plates

XXVII. and XXVIII.). It has been lately pointed out by the Duke of Bedford and Mr. Pickering (2) that the home-manufacture of lead arsenate—the best material for spraying in attacks by this insect—is inadvisable on account of the varying nature of commercial lead acetate and soda arsenate. Lead arsenate may now be obtained in a comparatively safe paste form ("Swift's") from Mr. D. M. Watson, of 61 South Great George's street, Dublin, who has been appointed agent in Ireland by the American manufacturers.

The Lackey Moth.

Clisiocampa neustria (Linn.).

(Plate XLI.)

This insect was reported as injurious in orchards from several districts in the South of Ireland, and I received in September a twig of apple surrounded by the characteristic cylindrical egg-mass of the species from Dungarvan, Co. Waterford. The moth belongs to the "Eggar" family (Lasiocampidæ), which comprises robust insects mostly brown or yellow in the colour of their wings, and with the jaws so reduced that they take no food in the winged condition. The feelers are strongly pectinated, especially in the male. *Clisiocampa neustria* has wings varying in colour from pale buff to dull red-brown, the forewing being crossed by a broad central band. In the male the wingspread is about 32 mm. (1¼ inch), in the female 38-43 mm. (over 1½ inch). The moths fly in July and August when the eggs are laid in the twigs of various trees, being closely grouped in rings surrounding the twig, and cemented so as to form a continuous hollow cylinder. The caterpillars are not hatched until the succeeding spring; then they may be found feeding from April till June. They have the habit of spinning, by their united labour, a sheet of silk web over the branches of their food-plant. Here they live in a community until fairly well-grown, finding in the web-nest an acceptable shelter, especially in wet weather.

When fully grown, the caterpillar is 50 mm. (2 inches) long and most striking and conspicuous in appearance. The head is blue-grey, with two black spots; the first thoracic segment is also greyish, with two large, black spots. The rest of the body is red-brown with various longitudinal stripes, black or grey, a broad, blue band along either side being especially conspicuous. A clothing of soft, yellow hairs covers the caterpillar. When it has attained its full size, the caterpillar becomes wandering in its habits, and about midsummer chooses some retired and convenient place in which to spin its firm, elongate cocoon, and pupate; cocoons may be found in a curled leaf, or on the bark of the food-tree, or in the crack of some neighbouring fence or wall. The pupal stage is short, and the moths are flying, as already mentioned, in late summer. (Barrett, 1, iii., p. 13.)

Spraying with the lead arsenate wash, as recommended for the winter moth caterpillar, is effectual also against this insect. The gregarious habit of the caterpillars, crowded together on their web, renders possible the simple remedy of cutting the shoot off, and letting it fall with the insects into a pail of paraffin and water.

Small Ermine Moths.

Hyponomeuta padellus (Linn.), and *H. malinella*, Zeller.

(Plate XLII.)

Caterpillars of these moths were sent from Co. Clare in May, with the complaint that they were proving destructive to apple-trees; while from Co. Waterford, Mr. J. Johnston, the County Agricultural Instructor, forwarded a large number of caterpillars, taken from hawthorn, stating that in parts of the county they had eaten the hedgerows almost bare of leaves.

These moths are easily recognized by their white or greyish forewings adorned with black spots, whence their name of "ermine." The species whose caterpillar commonly feeds on hawthorn is *Hyponomeuta padellus*, and it is generally considered that the apple-feeding caterpillars also belong to this moth. Theobald has lately given reasons (15, ii., pp. 31–34) for considering that the Hyponomeuta which eats apple foliage in these countries is identical with the Continental *H. malinella*, Zeller, and worthy of specific distinction from *H. padellus.* In *H. padellus* the head is pure white, the forewings light grey or whitish, with four longitudinal series of small black dots, only from four to six occurring in the lowest series; the fringes of the forewings are grey. The hind-wings are dark grey with pale grey fringes, whose tips are white. Theobald states that in the apple species (*H. malinella*) the hind-wing fringes are uniformly grey. *H. padellus* has a wingspread of 22 mm. ($\frac{11}{12}$ inch or less). According to Theobald, *H. malinella* is constantly smaller—17 mm. ($\frac{3}{4}$ inch).

The moths fly in July and August. They lay their eggs in groups of fifty or more, forming circular patches on the small twigs of the food-plant, covering them with a sticky, protective secretion which hardens and darkens on exposure to the air. The caterpillars are hatched in autumn, and remain under the protective covering just mentioned through the winter; in spring they emerge and enter the opening buds. Later they mine into the leaves, feeding for a while on the soft, green central tissue. In May and June they come out and feed externally on the foliage, spinning over the twigs and leaves a mass of web, which serves as a protective nest for a large community. Thus, in all stages of their lives, the caterpillars live in some kind of shelter. Towards midsummer they become fully grown. They are then about 25 mm. (1 inch) in length, with black heads, and bodies of a greenish or yellowish grey, spotted with black. They pupate in white spindle-shaped cocoons scattered about the web nests, from which the moths emerge in a few weeks. (See Plate XLII.)

On account of the protection afforded by the webs, arsenical spraying has but little effect upon these caterpillars in summer, though the use of caustic alkali wash in winter may be partially effective against the young larvæ. The most advisable practice is to cut off and collect the nests with the feeding caterpillars in May and June, either burning them or dropping them into pails of lime.

The Plum Aphid.

Aphis pruni, Réaumur.

Leaves of plum-trees, with numerous specimens of this common aphid, were received in June from the neighbourhood of Dublin. This is one of those species of aphid which cause the leaves, beneath which they live, to curl up, so that it is difficult to bring any wash to bear upon them. The life-history of this insect has lately been described by Theobald (15, ii. pp. 148–150). Spraying with quassia-wash, or paraffin emulsion very early in the season—the end of March, or beginning of April—when the first young aphids come out of the winter eggs, and before they multiply and begin to curl the leaves, is advisable ; such spraying should be repeated two or three times at intervals of a week. Autumn spraying—late in September—so as to kill the egg-laying females when on the trees, is also advantageous.

The Mussel Scale-Insect.

Mytilaspis pomorum (Bouché).

(Plate XLIII. A.)

This common and well-known scale-insect is doubtless present in numbers every year on apple-trees. Specimens were received from Co. Clare in May. In October, 1906, I received from Mr. G. O. Sherrard twigs from a peach-tree at Ballyhaise, Co. Cavan, terribly

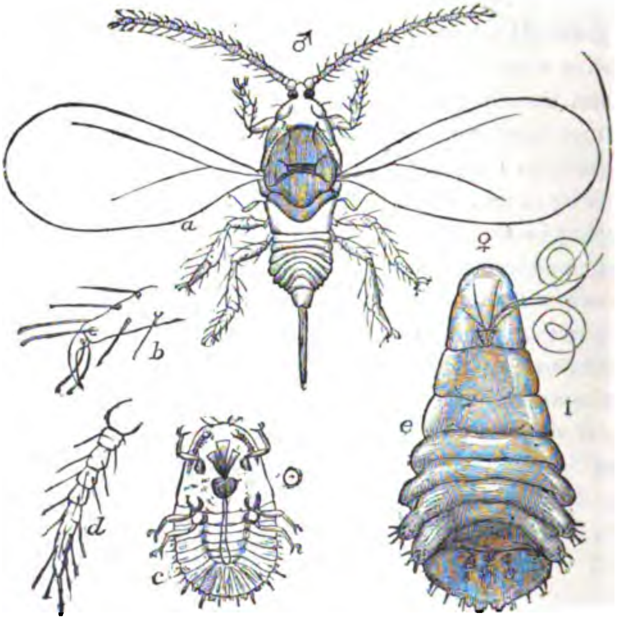

Fig. 6.—Mussel Scale-Insect (*Mytilaspis pomorum*, Bouché). (*a*) male, magnified 20 times ; (*b*) foot of male, more highly magnified ; (*c*) **larva** magnified 20 times ; (*d*) feeler of larva more highly **magnified** ; (*e*) female, ventral view, magnified 40 times.—From **Howard**, Year-book, U.S. Dept. Agr., 1894.

infested with these insects (Plate XLIII. A.), the familiar elongate female scales, about 3 mm. ($\frac{1}{8}$ inch) long, being crowded together so as to cover the bark almost entirely. The legless, swollen body of the adult female may be found under the narrow end of the scale in late summer and autumn, the broad end being filled with eggs—possibly up to eighty in number (fig. 7, *a b*). The scale, which is formed partly by the waxy secretion, and partly by the excrement of the insect, serves as a protective covering for the eggs, beneath which they can safely pass the winter. From these eggs the young larvæ (fig. 6, *c*) are hatched in May. They are white, flattened in form, and possessed of six legs, so that they run actively over the branches of their native tree. It is thought that they are often carried from tree to tree by wind, by birds, or by flying

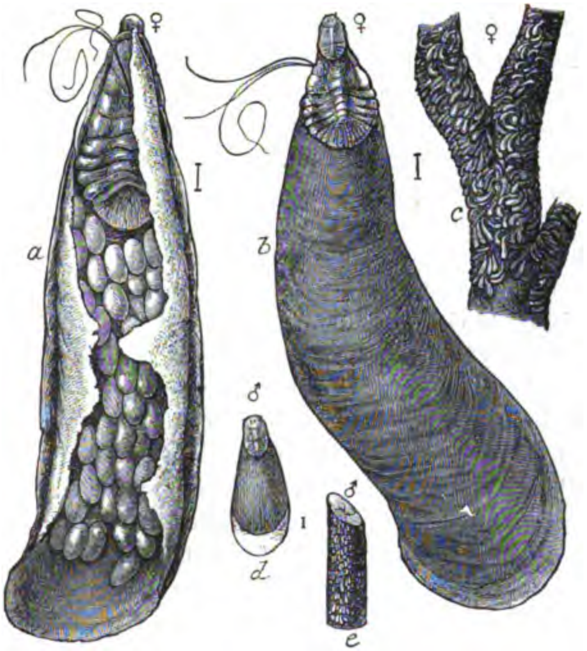

FIG. 7.—Mussel Scale-Insect (*Mytilaspis pomorum*, Bouché). (*a*) female from beneath, showing eggs protected by scale; (*b*) the same from above, magnified 24 times; (*c*) female and (*e*) male scales on twig, natural size; (*d*) male scale magnified 12 times.—From Howard, Year-book, U.S. Dept. Agr., 1894.

insects. A few days after hatching, the larva fixes itself, plunging its long proboscis into the bark, and commencing to secrete its protective scale. The legs disappear, and the insect becomes sluggish and motionless, though it continues to feed voraciously. If a male, the scale is complete in about six weeks, being then 1 mm. ($\frac{1}{25}$ inch long), and the insect assumes a resting "pupal" condition with distinct wing rudiments. In July the small, winged male (fig. 6, *a*) emerges from the scale and flies in search of his mate. The female is ready for fertilization in July or August, her scale being then about the same size as the male's. Afterwards it increases in size, as already mentioned. But the males are very scarce, and the females appear often to lay unfertilized eggs, affording an example of the virgin reproduction (parthenogenesis) often to be observed in this group of insects, and constantly among their allies, the Aphidæ.

For the destruction of scale-insects, paraffin emulsion should be applied in summer, and caustic alkali wash in winter. The emulsion acts directly on the insects, the paraffin being a "contact-poison." Newstead, from whose recent monograph (11) the preceding notes on the life-history of the Mussel scale are chiefly taken, recommends that half a pound of soap should be dissolved by boiling in a gallon of soft water, and that two gallons of paraffin should be added while the water is still hot, and the mixture well churned up with a syringe until it becomes white and creamy. Before use the emulsion must be diluted with nine times its bulk of hot, soft water, and again churned up with a syringe. Where practicable, the wash should be applied to the trees with a stiff brush. The ordinary caustic alkali wash used in winter is prepared by dissolving separately in water a pound of "commercial" caustic soda and a pound of crude potash ("pearl ash"). The two solutions are then mixed up together and a pound of soft soap is added, together with water, to make up ten gallons. This wash is beneficial to fruit-trees in several ways, destroying, for example, the shelters of many injurious insects; but it is doubtful whether it has much effect on the eggs of scale-insects. According to the recent work of Pickering (2), a caustic wash mixed with paraffin will undoubtedly kill the scale-insects' eggs.

Scale-Insects.

Lecanium capreæ (Linn.).

The apple-twigs from County Cavan mentioned above, infested with the Mussel-scales, had also a few examples of the much larger scale of *Lecanium capreæ*. The same species was also present on the peach branches from Ballyhaise. According to Newstead (11, ii., pp. 105–113), the larvæ are hatched in late summer and undergo their first moult before winter, fixing themselves permanently to the branches. The males are fully developed at the end of April or early in May, and the females lay their eggs in May and June, a single individual possibly producing 2,000 offspring.

The Spotted Millipede.

Blaniulus guttulatus (Bosc).

Strawberries bored by specimens of these slender, white, red-spotted millipedes were received from Tralee in June; they are well-known as frequently injurious to fruit in this way, and reference has already been made to the damage done by them to potato tubers (p. 434, above).

The Black-currant Mite.

Eriophyes ribis (Westwood).

As in previous years (4 (1904), pp. 260–2; (1905), pp. 301–2), the "big buds" on black-currant bushes, caused by these mites, again attracted notice in 1906. Red-currant shoots, also infested with the mites, were received in May from Co. Waterford, but their presence on that kind of fruit seems to have no serious effect. It has been lately stated by Collinge (6, pp. 5–8) that in the English midlands the mites have been completely cleared from infested plantations by dusting the bushes with unslacked lime (1 part), and flowers of sulphur (2 parts), three times during April and May at intervals of about three weeks. Apparently this application checks the migration of the mites from the old to the new buds.

GARDEN INSECTS, &c.

The Rose Scale-Insect.

Aulacaspis rosæ (Bouché).

Shoots of rose-trees covered with the conspicuous white scales of this species were received in November from Mr. P. J. Callan, who had obtained them at Clonakilty, Co. Cork. According to Newstead (11, i., pp. 168–173), the crimson eggs of this species are laid in August beneath the female scales, and the larvæ are already active in September. The male larvæ moult and settle down, commencing to form their scales in autumn ; but the female larvæ remain unchanged through the winter, moving about actively even during frosts, though sometimes they fix themselves to the shoots. In spring their development proceeds, and the females are ready for fecundation in May, the males having then completed their transformations and acquired their wings. The scale of the female is then completed, and her orange-red body may be found beneath it in late summer.

White Springtails.

Lipura ambulans (Linn.).

These small insects were again reported as injurious, information being received in February that they had damaged peas, beans, and other vegetables in a garden in County Dublin, eating across the young green shoots just below the ground. References to these springtails and their ravages during recent years will be found in former papers of this series (4 (1904), pp. 251–3 ; (1905), pp. 293–4 ; (1906), p. 340).

Vine Weevils.

Otiorrhynchus sp.

Complaint was received in November by the Editor of the *Farmers' Gazette* that the grubs of a species of Otiorrhynchus were injuring begonia tubers in a garden in County Wexford. For the destruction of these soft white grubs—often injurious to the roots of ornamental plants—watering with carbolic acid emulsion has been recommended by Theobald (15, ii., p. 160). A quart of soft soap is dissolved in a gallon of boiling soft water, and a pint of crude carbolic acid is added. This must be well churned up to form a creamy emulsion, and diluted with thirty times its bulk of water before use.

Enchytræid Worms.

Enchytræus albidus Henle.

From a garden at Killiney, County Dublin, soil was received in August, in which spinach was growing, containing numerous specimens of enchytræid worms. Mr. Rowland Southern has kindly identified them as belonging to the species *Enchytræus albidus*, Henle. References to damage in various parts of Ireland by similar worms may be found in my previous papers (4 (1903), pp. 202–3; (1905), pp. 297–8; (1907), 339). Theobald has recommended (15, ii., pp. 152–3) application of lime-water, prepared by mixing a pound of quicklime with a gallon of water and afterwards straining; or of corrosive sublimate, an ounce of the poison to six gallons of water.

FOREST INSECTS.

The Pine Weevil.

Hylobius abietis (Linn.).

Specimens of this well-known beetle were received in May from near Macroom, County Cork, both through the County Agricultural Instructor, Mr. T. A. Rudd, and also through the *Farmers' Gazette*. The beetles had done serious injury to a young plantation of larch and Scotch pine, the bark being eaten round at the base of the trunk, in some cases so completely that young trees had been killed outright. A notice with illustration of this insect and a short account of its life-history have already been given in this volume (4 (1902), pp. 154–5, Pl. I. c.).

The Pine Bark-beetle.

Hylurgus piniperda (Linn.).

During the winter of 1905–6 much damage was done in County Dublin by these small beetles boring into pine-shoots.

When these insects leave their breeding-places in summer or autumn, they bore into young shoots about two inches below the terminal bud and work their way upwards (fig. 8, 4), through the pith, finding in the centre of the shoot both food and shelter. A mass of resin exudes from the entrance hole, and the shoot, greatly weakened by the presence of the beetle, may droop or die, or be blown off by a winter storm. The loss of the shoots leads naturally to the deformation of the trees, and great damage may result to plantations from the attacks of these small beetles, which are only about 5 mm. (⅕ inch) in length, cylindrical in form, and dark-brown or black in colour.

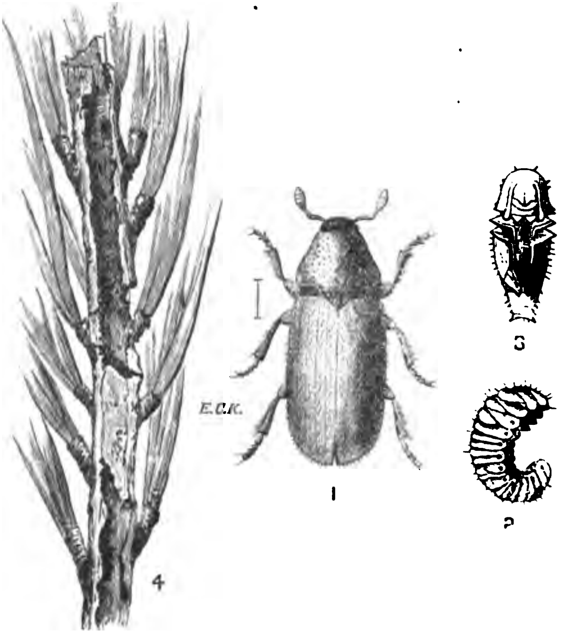

Fig. 8.—Pine Beetle (*Hylurgus piniperda*), magnified 6 times; 2, 3, larva and pupa, magnified 3 times; 4, tunnelled pine-shoot. From Omerod's "Reports."

The life-history of this beetle (fig. 8, 1) has long been well known. The insects come out from their winter shelters in April, when they make their way to pine-trunks for breeding purposes, choosing by preference trees that have been dead or felled for some months. The flow of sap in a sound living trunk renders such trees unacceptable to the insects, but if no dead trunks be available they will attack fairly healthy trees, which may suffer severely from their ravages. The male and female beetles pair and bore through the bark, the female making a fairly straight tunnel about four inches long between the bark and the wood, but mostly hollowed out of the former (fig. 9). As she forms her tunnel the female lays eggs alternately on either side of it to the number of perhaps a hundred. From the eggs are hatched stout, fleshy larvæ (fig. 8, 2), with white wrinkled cuticle and small, brown heads.

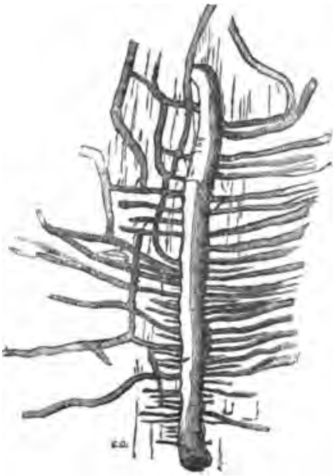

Fig. 9.—Burrows in pine-bark, made by *Hylurgus piniperda* and its larvæ. From Ormerod's "Reports."

These eat their way along tunnels of their own, which run outwards roughly at right angles from the mother's gallery (fig. 9). In about a month they become fully grown and pupate (fig. 8, 3) in ovoid chambers at the end of their tunnels. About a fortnight later the perfect beetles are developed, and they bore their way straight out from the pupating chambers through the bark, which looks, after their emergence, as if riddled with small shot.

Midsummer is the usual time when the new brood of beetles appear. These insects may proceed at once to bore into the young shoots as already described, postponing breeding till the next spring, or they may pair immediately and seek suitable trunks for egg-laying, repeating the operations of their parents and giving rise to a second generation of beetles, which appear in August, and then bore into the shoots. It is this habit of tunnelling the shoots which makes the beetle such a pest to the forester. And an abundant supply of beetles to do damage is assured by leaving felled trunks and dying trees lying neglected in the woods. In one locality which I visited, where scores of trees had been badly injured by the shoot-boring operations of the beetles, felled trunks with the bark on, beneath which thousands of beetles had developed, were lying about in all directions. A knowledge of the life-history of this insect indicates clearly the practical measures to adopt for its destruction. Felled trees may be left lying with their bark on, through the winter until spring, to attract the beetles to breed in them. Then, about the middle of May, when hundreds of larvæ and pupæ are living and feeding beneath the bark of these trunks, the bark should be removed and burned. Such a system of "trapping" is commonly adopted with success by the Continental foresters. The stumps of felled trees also are sometimes used as breeding-places by Hylurgus. These may be utilized as "traps" in the same way.

The Giant Sawfly.

Sirex gigas (Linn.).

(Plate XLIII. B.)

The year 1906 was remarkable on account of the large numbers of this conspicuous sawfly (or "wood-wasp") taken in various parts of Ireland. Most of the insects were females, and were obtained during July and August. The localities ranged from Gorey, County Wexford, to Kerry, Limerick, and to various places in County Longford. In the latter county the insect seemed to attract unusual attention, and a letter appeared in one of the Dublin newspapers recording the advent in Ireland of a "South African horsefly," which turned out on inquiry to be a female Sirex. Complaints were also received of injury to timber by the breeding larvæ of the insect. In one case the injured wood was from a tree which had been blown down three years previously.

Damaged or diseased trees are usually selected by the female Sirex for egg-laying; by means of her formidable ovipositor she places the eggs deep down in the wood, and the larvæ take some years to complete their growth. Cutting and using the timber may not lead to the death of the larvæ: according to Theobald (15, i., pp. 36–7), they may pupate and develop into flies even if the wood be creosoted. Hence it is desirable to cut down and burn all attacked trees, as the flies, if numerous, may seek healthy trees for egg-laying. The insect is so conspicuous that it may perhaps seem more abundant than it really is.

The Pine Sawfly.

Lophyrus pini (Linn.).

Caterpillars of the common pine sawfly (*Lophyrus pini*) were received in September from Belfast, with the information that they had caused much damage in the neighbourhood to Scotch and Austrian pines. This insect is frequently destructive to conifers in Great Britain, but it seems rarely to attract attention in Ireland. The species of Lophyrus are characterized by the strongly pectinated feelers of the male insect.

The male of *Lophyrus pini* has a wing-spread of 14 mm. (about ⅗ inch); it is black in colour with a red-tipped abdomen. The female is larger, measuring 20 mm. (⅘ inch) across the wings, and is yellow with darker thorax and a central longitudinal black band on the abdomen. There are usually two broods in the year, the flies first appearing in May when the female cuts slits in the pine needles with her ovipositor and lays her eggs, usually placing from six to ten in each slit, and covering them with resinous material scraped from the leaves. The caterpillars are hatched about a fortnight after the eggs have been laid. They feed in large companies on the pine-needles, also gnawing the bark of the shoots, and often doing much damage to the trees. They become fully grown at midsummer. By this time they have attained a length of 25 mm. (1 inch). They have eight pairs of abdominal pro-legs, in addition to the usual three pairs of legs on the thorax, and they are greenish in colour, with conspicuous black spots, pale-green when young, darker brownish-green when fully grown.

The midsummer larvæ form hard, oval cocoons among the leaves or in cracks of the bark, in which they pupate. These cocoons may serve as wintering shelters for the species; but usually the flies are developed in July and August, and come out to pair and produce a second brood of caterpillars which feed on the trees during August and September; the specimens received from Belfast belonged, of course, to this second brood. When fully grown, these autumn caterpillars form cocoons on the ground beneath the trees among fallen needles or moss, and rest unchanged through the winter. In the succeeding spring they pupate, and quickly develop into the May brood of flies.

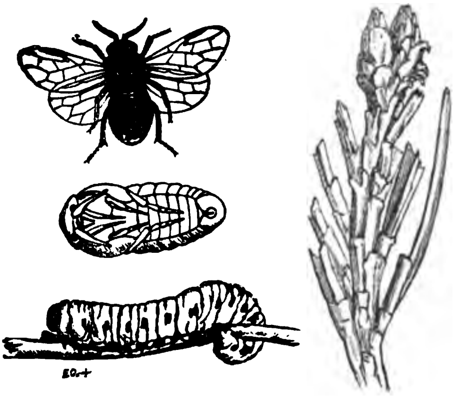

FIG. 10.—Pine Sawfly (*Lophyrus pini*), with pupa, larva, and injured shoot, slightly enlarged. From Ormerod's "Reports."

The conspicuous appearance of these caterpillars and their habit of feeding in companies make their destruction fairly easy. Shaking them off the trees so that they may fall on cloths, or crushing them in a mass with a gloved hand, have both been recommended. Theobald, who has given (15, ii., p. 165–9) a full account of this species and the allied *L. rufus* (Linn.), states that the larvæ migrate from a badly eaten tree to those around, and advises therefore that a ring of tar should be placed around an infested tree, and that the neighbouring trunks should also be banded. The clearance in winter of the refuse on the ground containing the hibernating cocoons is an obvious preventive measure.

The Willow Beetle.

Phyllodecta vulgatissima (Linn.).

(Plate XLIV.)

At the end of May complaint was made of damage caused to osier plantations near Lurgan by small beetles. Specimens were forwarded of the leaves eaten into holes by the insects, both adult beetles of the species *Phyllodecta vulgatissima* and their larvæ being present. The genus Phyllodecta belongs to the same family (Chrysomelidæ) as the turnip-flies, but not to the leaping section (Halticinæ) of that family, being included among the typical leaf beetles (Chrysomelinæ). In *P. vulgatissima* (fig. 11) there are irregular lines of punctures on the wing-cases, and the colour is metallic-green or blue. The nearly allied *P. vitellinæ* (Linn.), which is also frequently injurious to osiers and willows in the same way, is metallic-bronze, and has the puncturation regular. (See Fowler, 8, iv., p. 317). The larvæ (fig. 11 *b*) have a tough yellowish cuticle, with conspicuous brown bristle-bearing tubercles on each body-segment, the head and pro-thorax being hard and black. They are consequently well adapted for their exposed feeding habits on the leaves of osiers, wllows, and poplars.

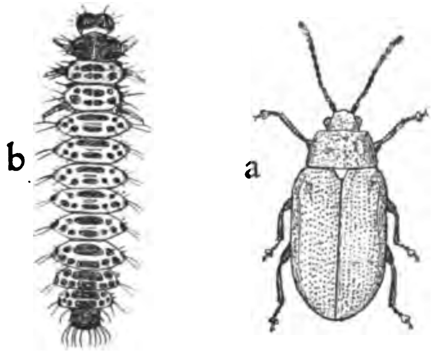

FIG. 11.—(*a*), Willow Beetle (*Phyllodecta vulgatissima*), and (*b*), its larva. Magnified 5 times.

As with many of the Coleoptera (beetles), these insects pass the winter in the adult state. According to Theobald (15, ii., pp. 163-5), they shelter at that season under stones and willow-bark, in the rubbish, leaves, &c., collected in old stumps, among fallen leaves on the ground, among heaps of osier-peel, or in the thatch of peelings used for huts in osier-beds, or between the overlapping boards of sheds or huts. Such shelters should therefore be, as far as possible, abolished. It is a good plan to lay in the autumn "traps" for the beetles, such as pieces of birch-bark or osier-peelings, gathered in heaps, which may be afterwards gathered and burnt with the beetles which have collected in them. If undisturbed, the beetles come out of their winter shelters in spring, and lay their eggs beneath the leaves. In a few days the larvæ are hatched; they begin to feed beneath the leaves, subsequently eating holes through to the upper surface. When fully grown, they fall to the ground and pupate in the soil, developing in autumn into beetles, which feed for a while on the leaves, and then hibernate, as already mentioned. When the beetles and their larvæ are actually feeding in spring and summer, they may be shaken off the shoots, and caught on tarred sacks or boards. Spraying with arsenical wash—Paris green or lead arsenate—may be also confidently recommended. As the beetles may winter in flood-rubbish, it is advisable to burn this before spring.

The Osier Gall-Midge.

Rhabdophaga heterobia (Loew.).

In a previous paper of this series (4 (1905), pp. 302-4, Pl. xxvi. B) will be found an account of this midge, with reference to the damage done by its larvæ to osier plantations in County Kilkenny. During the summer of 1906, I received, through Mr. Armstrong, Superintendent of the Richmond Institution for the Blind in Dublin, galled osier shoots from Ardee, County Louth, and Mr. Armstrong informed me that the insect had done great damage to plantations in that locality, as well as in County Meath. Since my last notice of this insect, some notes on its life-history have been published by MacDougall (10), who succeeded in rearing, from galled buds, specimens of the perfect midges which emerged in July. Mr. Armstrong was so good as to send me galled shoots at intervals through the winter of 1906, and I noticed that by February, the number of larvæ in each gall showed a reduction, only three or four being present, instead of the eight or nine to be found in summer. Careful search through a quantity of soil from beneath the osiers, kindly procured and sent by Mr. Armstrong, failed to discover any buried larvæ. I carried out this examination, thinking it possible that there might be a winter brood of buried pupæ. No support of this view was forthcoming, but the disappearance of larvæ from the galls in February suggests that there may be a very early spring brood of midges, the species having two life-cycles in the year.

HOUSE INSECTS.

The Mottled Willow Moth.

Caradrina quadripunctata, Borkh.

In the last of this series of papers (4 (1906), p. 343), reference was made to the invasion of a dwelling-house at Kilbeggan, County Westmeath, by hundreds of caterpillars of this moth. It is of interest to find from Theobald's recent report (16, pp. 103–4), that a similar occurrence was noted at Portora, Enniskillen, where these caterpillars, which " were swarming in a hay-loft, found their way in large numbers into an adjacent bedroom, in spite of all measures taken to exclude them." The occurrence of multitudes of these caterpillars in a warehouse at Douglas, Isle of Man, was noticed in 1898 by Mr. H. Shortidge Clarke (17).

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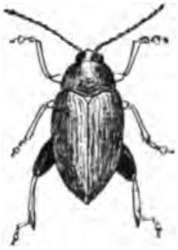
EXPLANATION OF PLATE XXXIX.

PLATE XXXIX.

A. Cabbage Beetle (*Psylliodes chrysocephala*). Magnified 5 times.

B. (i) Cabbage plant injured by larva of *Psylliodes chrysocephala*, showing hole through which newly-hatched larva enters the plant. (ii) Cabbage plant split open to show central cavity and decaying tissue due to the presence of the *Psylliodes* larva. From Carpenter, *Journ. Econ. Biol.*, vol. i. Photographed by T. Price.



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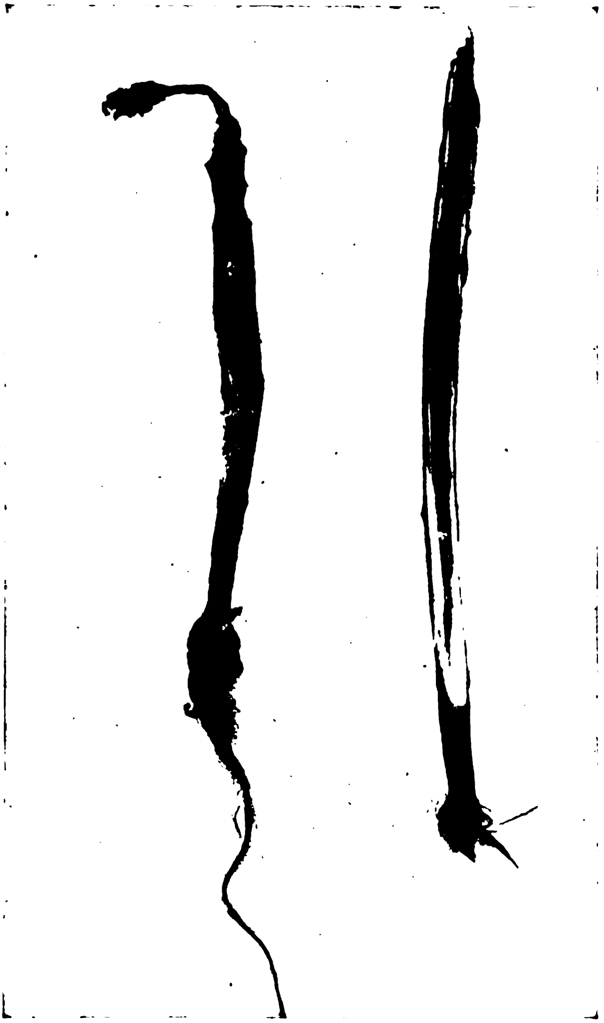


i. ii.

B

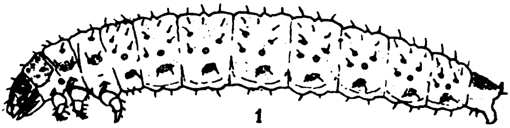
EXPLANATION OF PLATE XL.

PLATE XL.

Fig.

1.—Larva of *Psylliodes chrysocephala*. Lateral view. × 8.
2. ,, ,, ,, Head, ventral view. × 32.
3. ,, ,, ,, Right feeler, ventral view. × 240.
4. ,, ,, ,, Head, dorsal view. × 32.
5. ,, ,, ,, Head, lateral view. × 32.
6. ,, ,, ,, Hinder abdominal segments, dorsal view. × 16.
7. ,, ,, ,, Fourth abdominal segment, lateral view. × 16.
8. ,, ,, ,, Left hind leg. × 48.
9. ,, ,, ,, Hind foot, showing claw and tunica. × 240.
10. ,, ,, ,, Labrum, ventral view. × 160.
11. ,, ,, ,, Left Mandible. × 160.
12. ,, ,, ,, Right Maxilla. × 160.
13. ,, ,, ,, Labium. × 160.

After Carpenter, *Journ. Econ. Biol.*, vol i.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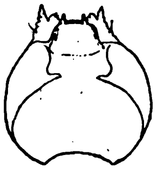
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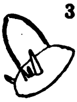
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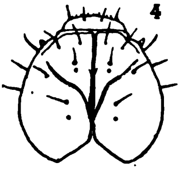
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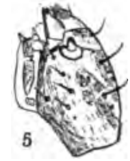
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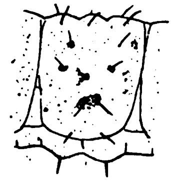
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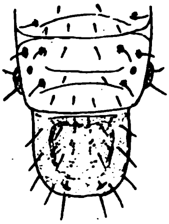

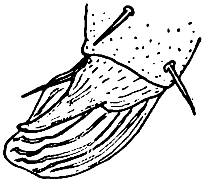
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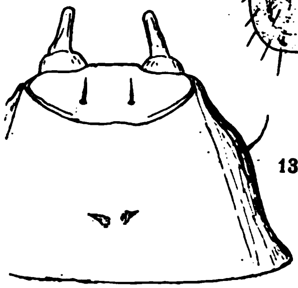
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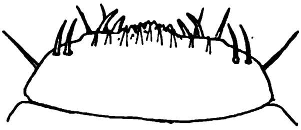
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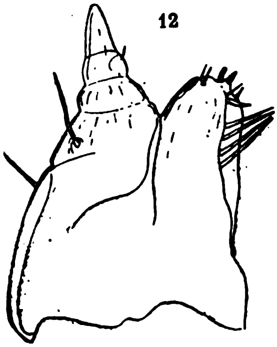

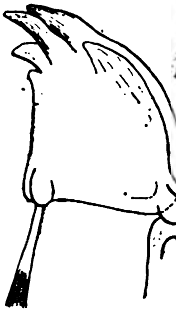
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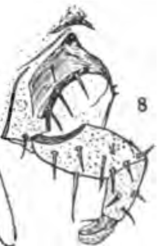
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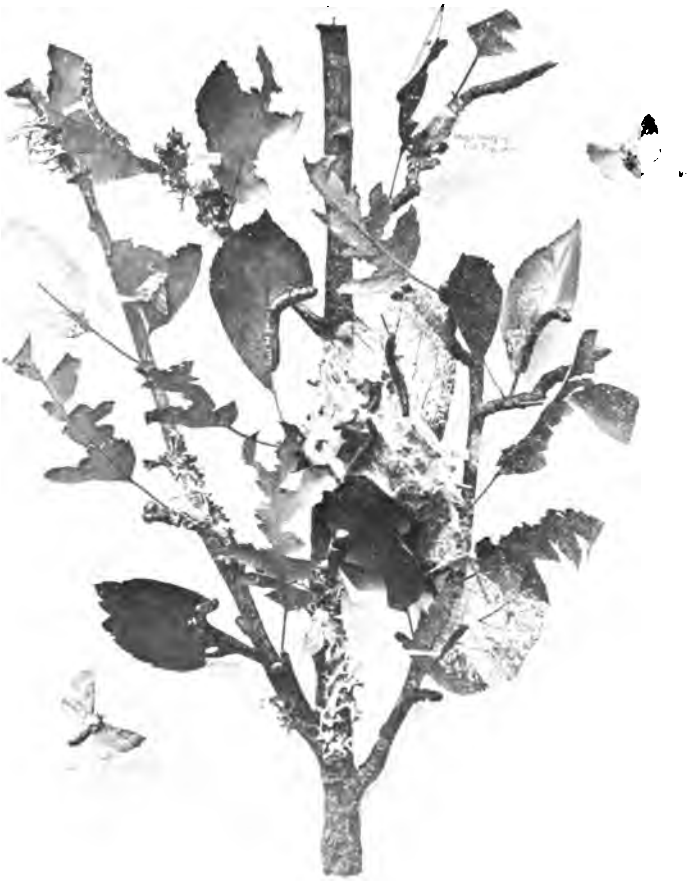
EXPLANATION OF PLATE XLI.

PLATE XLI.

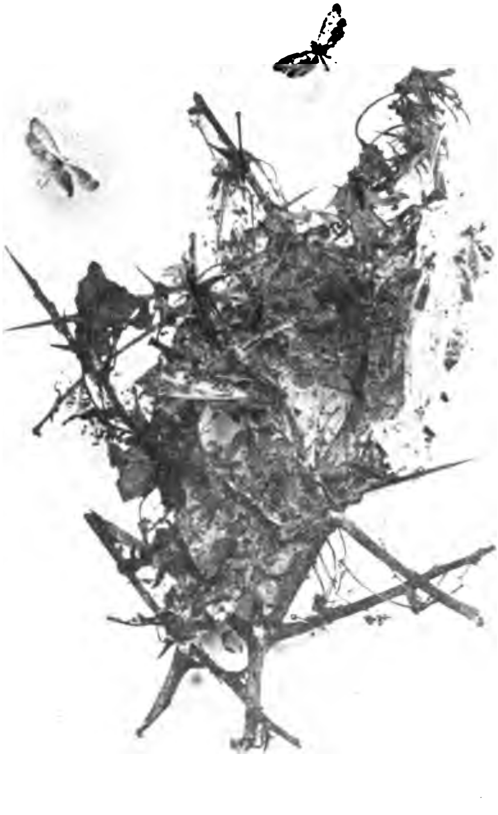
Stages in the life-history of the Lackey Moth (*Clisiocampa neustria*).
Photographed from an exhibit in the Dublin Museum by T. Price.



EXPLANATION OF PLATE XLII.

PLATE XLII.

Small Ermine Moths (*Hyponomeuta padellus*), with Caterpillars on silken web spun over Hawthorn. To the right are Cocoons containing pupæ. Photographed by T. Price.

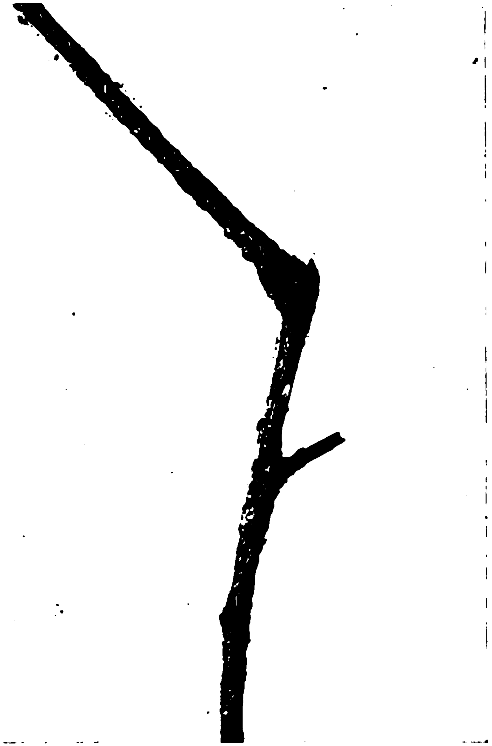


EXPLANATION OF PLATE XLIII.

PLATE XLIII.

A. Peach twig covered with scales of *Mytilaspis pomorum* and a few of *Lecanium capreæ*. Photographed by T. Price.

B. Stages in the life-history of the Giant Sawfly (*Sirex gigas*). Photographed from an exhibit in the Dublin Museum by T. Price.



A

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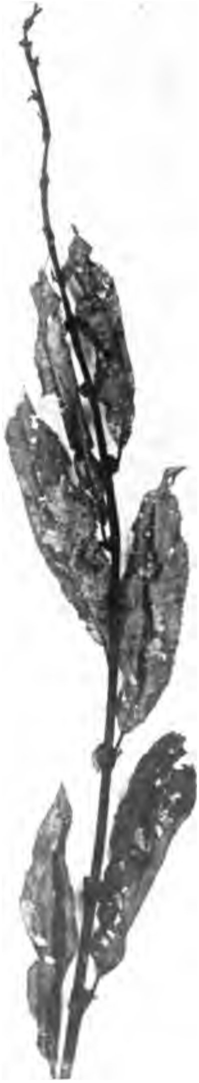
EXPLANATION OF PLATE XLIV.

PLATE XLIV.

Osier Leaves eaten by Willow-beetles (*Phyllodecta vulgatissima*) and their larvæ. Photographed by T. Price.



XX.

SPONGOSPORA SOLANI, Brunch.

(Corky Scab.)

By T. JOHNSON, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.

(Plate XLV.)

[Read, February 18 ; Received for Publication, February 20 ;
Published, April 6, 1908.]

Last year (1907) I spent the greater part of the summer vacation on an inquiry into the nature and extent of "Yellow Blight" in the potato crop in the West of Ireland. I visited more especially counties Kerry, Galway, Mayo, and Donegal. I was struck in the first plots I visited in the Dingle peninsula by the scabbiness of the potato-tubers, and found to my surprise the scabby spots showed spore-balls of *Spongospora solani*, which I have already recorded from County Dublin[1] as a rare British slime-fungus, of apparently biological interest only. I was astonished in the course of my visit to find the *Spongospora* scab everywhere. Roughly speaking, every plot of potatoes in the districts I visited showed the scab. What connexion, if any, it has with yellow blight I cannot at present say. Experiments now being undertaken must decide this. That the scab damages the tubers very much is clear from the illustration (Plate XLV).

Such tubers are not only much reduced in market value for eating purposes, but must provide also poor seed for the next year's crop. Yet I was constantly told that this was the kind of seed regularly planted from year to year; and that the people used this seed because they had, and could get, no other. It is unfortunate that amongst farmers there is a general impression that scabbiness in a potato-tuber is a sign of its excellence. I have no doubt myself that this *Spongospora* scab has a good deal to do with the miserable average yield per acre of potatoes in the west of Ireland.

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[1] The owner of this garden was a frequent visitor to the West, and probably brought home scabby seed-tubers on one of his visits.

The scab in a pronounced case is readily recognizable by anyone provided with a good pocket lens. Inspection of the damaged skin of the tubers shows a number of yellow-brown particles lying in little pockets, comparable to grains of sand, and just visible to the naked eye. These are the spore-balls by which the disease is propagated from year to year. In the first stage of attack the tuber skin is raised above the general surface, the patch being as much as $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in diameter. The surface of the raised skin becomes ruptured, and the spore-balls become exposed like loose grains. The elevation becomes a depression as the balls fall away, and gradually the depression becomes deeper and wider. I have seen spore-balls lining the exposed surface of excavations an inch deep. The parasite literally gnaws away the substance of the tuber, which in some cases, however, successfully resists the enemy by forming a protecting layer of cork. This protection is, I think, more usually developed when the tuber is attacked from without by the scab-spores present in the soil.

The disease was first accurately observed by Brunchorst[1] in 1886, who describes it as common throughout Norway, and as probably the general cause of potato scab everywhere. Frank mentions it in his text-book of Plant Diseases as quite a rarity in Germany (he gives two localities only), and concluded that *Spongospora* was for Germany a rare organism, of a Northern type, and of a saprophytic character; that it was, in fact, a secondary accompaniment of scab, and not responsible for it. Frank altogether underestimated its destructive parasitic character. It is in some districts in Ireland as injurious to potatoes as finger-and-toe is to turnips.

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[1] Though Brunchorst failed to make out the structure of the spores, to obtain their germination, or to observe the movement of protoplasm characteristic of a plasmodium, he concluded that *Spongospora solani* is a slime-fungus. In my paper, read before the German Society of Applied Botanists, I was able to throw a little more light on the organism, both as regards its spores and plasmodium. The discovery of its destructive abundance in the West last summer compelled me to renew the attack; and this winter has been devoted as far as available to an examination of the structure and life-history of the organism, and to the ascertainment of the means of prevention of *Spongospora* scab.

Examination of a spore-ball, $\frac{1}{100}$ to $\frac{1}{1000}$ inch in diameter, under the microscope shows it to consist of hundreds of spores, which are only 3·5 μ in diameter, or about half the size of a red-blood corpuscle. The spores are polyhedral cells, and in optical section hexagonal or octagonal. Their walls are bright bottle-green, thickened at the corners and readily stained. Between the spores small intercellular spaces exist; but, in addition, the ball possesses a feature which caused Brunchorst to call the fungus *Spongospora*. The ball is like a sponge, in which the substance of the sponge is represented by the spores in groups or chains, and the spaces in the sponge are the gaps between the spores. The spore-ball is thus a mass of spores, honeycombed by intercellular passages. The spore contents showed no organization to Brunchorst, except for a possible nucleus, owing to their smallness; and every means he tried failed to cause them to show any signs of life. As a result of my work in 1906 I was in a position to say that some of the spores when stained showed several small bodies inside them; that others, with no contents or with one or two motile bodies in the cavity, had their wall perforated. I could not decide whether these moving bodies were external and microbic in origin, i.e., intruders through the pore, or swarm-spores not yet escaped.

In the autumn of 1907 I started a series of cultures to try and induce these apparently passive spores to sprout. Some of the tubers were soaked in Appel's Potato Gelatine, others in addition were given a little Papayotin, a peptonizing ferment, and others a few drops of a very diluted solution of KHO, because the HO ions, as discovered by A. Fischer, have a stimulating effect on protoplasm. Hanging drops of these decoctions and of water only; moist chambers of blotting-paper, soaked in potato decoction; cultures in potato broth on porous porcelain; and various other means were tried to make the spores germinate. Sterilization of the decoctions, and of everything possible used, short of injuring the spore-balls, was practised. Most of the cultures were kept in darkness in an incubator, maintained generally at 20° C.

By these various methods I was enabled to make out a great deal of the organization of the spores. In spore-balls, not quite ripe, the contents of the spore appear as one fairly dense body. In riper balls, nearer the potato surface, the contents are seen to consist of distinct bodies—six or eight in number. Frequently in culture the spores are to be seen with a perforated wall, often with no contents. Every day for the past few months, and sometimes for hours at a time, I have watched the spores, magnified 1,000 times or more. In one or more spores of each ball, after some hours under culture conditions, I have constantly found one or more motile bodies. In one case I saw six or eight, looking as if they could not possibly be intruders. Spite of the time spent by my assistant, Miss Hensman, and myself, I have never seen these motile bodies leave the spore, though I saw many bodies like them in the field under the microscope. I decided to supplement the examination of fresh culture material by that of killed and stained preparations. I used for this purpose Flemming's fixing mixture, and his three-colour stain, modified as recommended by Nawaschin and Swingle, as well as the two-colour iron-hematoxylin stain. The results were highly satisfactory. The spores showed all stages of development—an undivided one-nucleate body, others bi-nucleate, others with four, and others with apparently eight distinctly nucleate bodies. As the whole spore itself is 3.5 μ in diameter, or twice the size only of the nucleus Yeast-plant, I found the contents too small to permit me to follow out the exact mode of division. Sometimes I saw what appeared to be small degenerate nuclei side by side with normal ones, as described by Jahn in other Myxomycetes. I am, however, now satisfied that the motile bodies I saw in the fresh material were not intruders, but swarm-spores. Thus, although the contents of the spore may possibly sometimes escape before division, generally they divide to form some eight slightly pear-shaped swarm-spores which escape into the surrounding medium, and serve to propagate the *Spongospora.* This is so different from the general procedure in the slime-fungi or Myxomycetes, where the contents escape from the spore as a single swarm-spore, that I hesitated to think it probable. Jahn, however, in 1907, published an account of his investigation of *Ceratiomyxa,* the lowest of the group. He finds the ripe spore of *Ceratiomyxa* possesses four small nuclei, each of which divides into two, so that from the quadri-nucleate amœboid body which leaves the spore-case, eight uni-nucleate swarm-spores are formed. The spore of *Spongospora* behaves very much like that of *Ceratiomyxa*, and thus from one spore some eight swarm-spores apparently arise.

As I am anxious that the contents of my paper should be available for utilization this season, I am not delaying the publication by the inclusion of general illustrations. These will follow when the story is more complete.

The preparations I have examined support the following interpretation:—In the plasmodium the spores become outlined, with one nucleus in each area; next, the spore-walls, though thin, are clearly visible. In the protoplasm, instead of one, several granular bodies (eight? nuclei) are recognizable. The spore-wall is thicker; and in the spore there is one much enlarged, deeply-stained nucleus, and one or more degenerate nuclei. Judging from *Ceratiomyxa*, we have here karyogamy accompanied by degeneration of the unfused nuclei. Next, this enlarged single nucleus divides into two, these into two, and these again into two, giving eight nuclei in the one spore. Each nucleus represents one swarm-spore. The many questions of biological interest here raised I must leave for subsequent treatment. So far I have not succeeded in tracing the fate of the swarm-spores. I have seen amœboid bodies which might very well be young plasmodia; but their intermediate links are missing in my observations. A vertical section of a potato tuber through a *Spongospora* scab-spot shows the spore-balls, as already mentioned, in different degrees of ripeness—the youngest are deepest in the skin, and the oldest nearest the free surface. In cells of the cork-cambium, or near it, a body similar in size to the spore-ball may be seen. It may fill the whole cell, or sometimes only part of it. It is a densely granular body, with large vacuoles. The vacuoles represent the gaps or passages between the spores in the spongy spore-balls. These passages, owing to their mode of origin, represent a new type of intercellular space, and may be called *plasmogenetic*, to distinguish them from *schizogenetic* (by splitting of cell-wall), and *lysigenetic* (by breaking down of cells) intercellular spaces. I am hoping, during the active vegetative period of the scabbed tubers, to see not only this plasmodium in motion, but to trace the stages in its transition to the ripe spore-balls. *Spongospora* is closely allied to the slime-fungus *Plasmodiophora*, which causes finger-and-toe in Turnip and other Cruciferae.

Woronin, in 1878, was the first to work out the general life-history of this pest; and in 1899, Nawaschin, by the help of Flemming's method, completed the story of the life of the fungus, more especially as regards its intra-cellular existence in the turnip-cells. Nawaschin found no sign of the plasmodium passing from cell to cell in the turnip. His illustrations show the parasitic plasmodium side by side with the host protoplasm, disputing with it the cell-space, and ultimately devouring and displacing it. I have seen a precisely similar process going on in the scabby potato-tuber, and have checked my observations by comparison with the healthy tuber, fixed and stained by the Flemming method. Near the surface of the tuber are the fully developed plasmodia, densely granular, about to become converted into spore-balls. Deeper in, these plasmodia are smaller, less dense, and occupy less space in the host-cell. The starch grains gradually disappear; and I have seen the host nucleus attacked and partly destroyed by the plasmodium. The plasmodium passes probably from cell to cell of the host through perforations in the cell-wall; but this point needs further examination. In 1905 I planted a scabby tuber and found the crop scabby, indicating that the disease passes from the seed-tuber to the new crop of tubers as a plasmodium, through the haulm and branches of the rhizome. I have seen the scab on a rhizomatous branch itself. The experiment shows that the scabby seed-tubers, planted in the West, produce their crop of scabby tubers year by year. Although I have not yet caused a healthy tuber to become scabby by inoculating it with *Spongospora*, I am quite satisfied that *Spongospora* is a true parasite, doing an immense amount of harm in the West to the potato crops. As the balls lie quite free, when ripe, on the surface of the tuber, many must fall off into the soil, especially when the potatoes are dug. In this way, no doubt, healthy tubers put into scabby ground become diseased. I saw many varieties of potatoes in cultivation, in all kinds of soil; and although the scab seemed more pronounced in Kerry than in Donegal, there was nothing to suggest that one variety of soil favoured scab more than another. Experiments devised to test this question are desirable.

PREVENTION OF THE DISEASE.

Having ascertained the conditions necessary to cause the spores to germinate, I proceeded to treat the scabby tuber with various fungicides to kill the spores, using such fungicides as are known, when applied of definite strength for a limited time, not to injure the potato tuber. I found 2 per cent. Bordeaux mixture for 18 to 24 hours, 0·1 per cent. corrosive sublimate for 1½ hours, 0·4 per cent. formalin for 2 hours effective in killing the spores. It is known that such treatment does not injure the tubers. Hence I would strongly advise all growers of potato tubers to soak the seed-tubers before boxing or planting in a 2 per cent. Bordeaux mixture for not more than 18 hours.[1] The tubers will not be injured, but scab and other troubles will be much lessened. Such steeping becomes more necessary the further west one goes. The tubers should be spread out and turned over to dry before planting. Mr. Wade found that after twenty-four hours' steeping in Bordeaux solution the tubers rotted in the ground. Judging from my laboratory experience, when well dried after steeping they do not rot.

Keeping in mind what is known of the mode of life of other slime-fungi, the life-history of *Spongospora* seems to be very much as follows:—

A scabby potato is planted and sprouts. The stored solid proteid (crystalloids) and carbohydrate bodies (starch grains) in the tuber become diffusible. The resting plasmodium of *Spongospora* in the host-cells becomes at the same time actively motile, and feeds on the now available organic food-materials of the host-cells. As the potato-eye sprouts and forms a shoot, the parasitic plasmodium passes into it. The shoot develops and gives off branches and tubers into which the parasitic plasmodium passes, living on the host-cells' contents in its passage. In the growing tuber the plasmodium luxuriates. As the tuber ripens, with loss of water and solidification or precipitation of its stored organic matter, the plasmodium creeps towards the surface of the tuber and becomes converted into spore-balls, usually one in each host-cell. The spore-balls raise the skin of the tuber, which peels off, leaving exposed a wound full of spore-balls. These are like so much loose powder, and fall into the soil. The exposed surface is roughly comparable in appearance to the broken surface of a coarse piece of cork, and a popular name for this *Spongospora* scab might be "corky scab."[1] If the soil and tuber are very wet, the tuber is unable to protect itself by the formation of wound-cork against a continuance of the gnawing process. Fresh spore-balls are formed, and the scab-spot, which began as a little hump, becomes a deeper and deeper pit. What happens to the spore-balls in the ground during the winter is still a matter for investigation. In all probability they lie dormant to sprout in the spring at the same time as the planted potato tubers sprout. Possibly the manure—one kind more than another—stimulates the spores to germinate, just as the food solutions I have used in the laboratory do. The swarm-spores probably find their way into the tuber through the lenticels, through the sprouting eyes, through the exposed surface of the cut-sets of the tuber, or through wounds made by worms or insects, and there they develop the plasmodium. If this view is correct—and everything I know supports it—it is unnecessary to emphasize the precautions I mention in the following summary.

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[1] **Mr. R. J. Moss, F.C.S., thinks copper sulphate alone would be equally effective, less expensive, and also less troublesome.**

It will not be without interest to call attention here to another form of scab from which Ireland is at present apparently free. This is the form called black scab, due to a microscopic parasitic Chytridian called *Chrysophlyctis endobiotica*, Schilb., first observed in Hungary by Schilbersky in 1886, and recorded from Cheshire in 1902 by M. C. Potter, and now spreading in an alarming manner through England and Scotland. I received specimens of this disease from Mr. Newstead of the Chester Museum several years ago; and within the past few days one from the Director of the Royal Botanic Gardens, Kew.

The parasite causes wart-like excrescences on the tuber, and, in addition to reproducing itself by zoosporangia, forms isolated

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[1] Mr. R. Hunter Pringle, of the Local Government Board, tells me that *Spongospora* scab looks much like "corky end," a disease of unknown nature to be seen in tubers in the district round Glasgow.

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resting-spores thirty times the size of the spores of *Spongospora.* Potter has failed to induce these spores to sprout, though they are known to do so in nature and spread the disease.

Through the kindness of Colonel Prain, F.R.S., the Director of the Royal Botanic Gardens, Kew, I have been able to compare type herbarium material of *Sorosporium scabies* (Berk.) Fischer d. Wald. with *Spongospora solani*, Brunch. I can see no difference in size or structure of the spore-balls of the two, and believe microscopic examination of restored material will show that *Sorosporium scabies* with its "glomerulis 1-2 lacunosis" should be removed from the *Ustilagineæ*—that it is really *Spongospora solani.*

SUMMARY.

1. I regard *Spongospora solani* as a dangerous parasite, allied to the slime-fungi *Ceratiomyxa* and *Plasmodiophora.*

2. A potato-crop becomes scabby:—

(*a*) By planting healthy tubers in scabby soil.

The parasite enters the tuber, probably through the cortical pores or the young shoots, or through wounds caused by worms, insects, &c. Where the soil is wet and close the lenticels show a morbid state or extuberance, and in this state provide an easier entrance for the fungus.

(*b*) By planting scabby tubers.

In this case the plasmodium probably passes from the diseased seed through the sprouting eyes into the new tubers, making them scabby.

3. Other causes, in addition to want of drainage and aëration of the soil, may tend to increase the virulence of the parasite or the predisposition of the potato to disease. These need investigation. Excessive liming or nitrogenous manure, poorness of soil in potash or phosphates suggest themselves.

4. Crop rotation. Ground should be kept free from potatoes for at least two seasons, to allow time for the potatoes' enemies to

die. I know that in the West it is not easy to adopt this rotation. In most districts, year after year, potatoes and oats follow one another. In one district I visited potatoes have followed potatoes for more than fifty years.

5. The minimum of three years' rotation should be associated with the planting of fresh healthy seed. This, I admit, is difficult to procure—more difficult than most people imagine.

6. Seed-tubers, before boxing or planting, should be steeped, for not more than 18 hours, in a 2 per cent. solution of Bordeaux mixture, made as used for spraying, or in a 2 per cent. solution of copper sulphate.

7. Uncut tubers, about twice the size of a walnut, and weighing 3½ oz., should be planted. Where the tubers are cut—and this is usual in the West—the sets should be stored for two or three days in a not too warm or dry place, to allow a protective layer of cork to form over the cut surface.

8. The sets should not be planted in direct contact with the manure, as this is one of the surest ways of promoting disease.

9. Where the soil is given to scab, it would be an advantage to sprinkle sulphur, or other disinfectant, on its surface where the sets are being planted. Sulphur, not lime, should be used for coating tubers, or cut sets, in store.

10. Scabby tubers, too far gone for use, should be destroyed by lime or buried deep—not left to infect the soil, or to be thrown on to the manure heap.

11. Genuine cultivation of the potato—not mere planting—need hardly be mentioned as a necessity. Drainage, suitable manure, destruction of weeds, cannot be neglected without loss.

I made somewhat similar suggestions to these in my paper entitled "Some Injurious Fungi found in Ireland,"[1] without, I am afraid, much effect. Yet, it is the neglect of such suggested precautions which accounts largely for the present precarious state of the potato industry. I am thoroughly convinced that the prevalence of yellow blight and of scab in the potato crop in the West, not to mention the ordinary leaf-blight, is largely due to the planting of diseased seed. It is the exception to see healthy tubers. Nearly every tuber I have examined showed some sign of disease. Unfortunately, the steps taken to make sure, when fresh seed is obtained, that the tubers are healthy, are not enough. Though the practical man will be inclined to laugh at me for saying so, the inspection needs to be more scientific, more botanical, in character. The ordinary naked-eye examination of a cut tuber is not thorough enough. Tubers with yellow-blight germs in them, and unsuitable for seed, pass such an examination. The growing crop itself, from which the seed-tubers are obtained, should also be examined. Ireland, I need not mention, does not possess a monopoly of potato diseases. Yellow blight, in two of its common forms in Ireland, occurs, as I have myself ascertained, in Scotland; and it would be interesting to know how far imported Scotch seed is responsible for disease in Ireland. The only serious case of scab I have seen in the East of Ireland was one of Black Skerries, in County Antrim, in tubers sent for examination by Mr. Marchbanks, one of the Department's Instructors. Where did the seed of these come from?[1] In Germany, within the last few weeks, Count Arnim has caused great alarm amongst agriculturists by his revelations, under the title "Europe's Potato Industry in Danger," of the diseased condition of potatoes in Germany, Denmark, and Sweden. He has been known for some time past as a skilled producer of potato varieties, has a research laboratory on his property, and last year examined 400 of the 2,000 varieties of potatoes in cultivation. He is inclined to say that there is not a healthy tuber in Germany. The potato crop in Germany, for 1907, was officially estimated at 45½ million tons, of which only 6·4 per cent. was returned as diseased. This shows, says Count Arnim, that the great majority of the agriculturists only regard as diseased such tubers as are seen from external examination to be rotten or rotting. The diseases which are doing such harm in the growing crop are, though present, practically unrecognized by them in the tubers. He estimates the loss in Germany, in the potato crop for 1908, through planting the diseased seed-tubers of 1907, will be at least £30,000,000. Germany's crop averages 6–7 tons per acre, Ireland's about 3 tons. What is Ireland's preventible annual loss? Count Arnim urges the German Government to attack the problem of saving the potato industry, at once and thoroughly, as to do so will save money in the end. He would organize an inquiry, in which practical and scientific men would combine, having as its main objects—1. The production of disease-proof varieties to replace the diseased ones now in cultivation, and going from bad to worse. 2. Investigation of the diseases. 3. Soil-disinfection, manurial tests, &c. His warnings—and he is no dreamer—apply with full force to Ireland. The German trouble, in its present intense form, began to be noticeable in 1901, in two special forms of disease. The trouble in the West of Ireland goes back many years. It is not simply that the crop is reduced in amount by planting diseased tubers, many of which fail, but the resulting crop is itself diseased. Vigorous action is needed in Ireland, as much as in Germany. I have seen enough of the Department's Overseers and Instructors in the country to know how much good work they are doing; but the forces at present available are altogether inadequate. The problem is a national one, and is too grave and pressing to be left to private enterprise.

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[1] Econ. Proc., Roy. Dubl. Soc., Vol. I., Part ix., p. 349.

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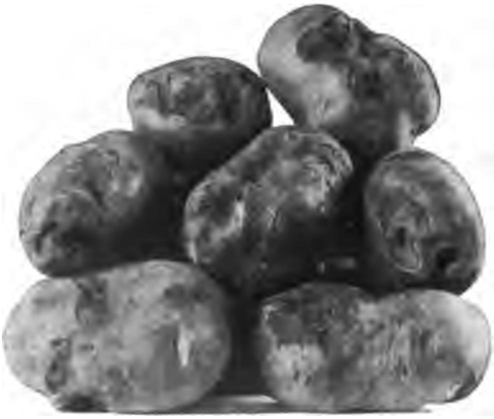
[1] While this paper has been going through the press, I have reported for the Department of Agriculture on tubers showing *Spongospora* scab. The tubers are Scotch "champions" sent from Perthshire for seed purposes.

EXPLANATION OF PLATE XLV.

PLATE XLV.

Potato-tubers infested with *Spongospora solani*, Brunch.



POTATO-TUBERS INFESTED WITH *Spongospora solani*, BRUNCH.

XXI.

REPORTS UPON THE IRISH PEAT INDUSTRIES: PART II.

By HUGH RYAN, M.A., D.Sc., University College, Dublin.

(Plates XLVI. and XLVII.)

[Read, March 24; Received for Publication, March 31;
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Section I.—The Peat Fuel Industries.

1. *Properties of Fuel.*

The essential properties of fuel are:—

(*a*) It must be capable of continuing to burn in the air after ignition has been started: that is, the chemical reactions, which take place between its constituents and the oxygen of the air, must be attended by the development of a quantity of heat sufficient to keep the temperature of the reacting substances at or above the ignition point.

(*b*) The products of combustion must be mainly gases, must not corrode metals, and must not be injurious to human life.

Of the many elements known, there are only two (carbon and hydrogen) whose compounds fulfil all the above conditions. The carbon compounds more commonly employed as fuel are:—Plant-fibre, and its decomposition products (peat, lignite, and coal).

When a fuel such as turf burns in air, the chief chemical changes which take place are:—

(*a*) The union of the carbon and hydrogen of the turf with the oxygen of the air to form carbon dioxide and water respectively.

(*b*) The conversion of the turf into volatile liquids like petroleum, or gases such as methane, hydrogen, and carbonic oxide, which afterwards burn in the fire on coming in contact with air.

(*c*) The mineral or earthy matters of the turf remain in the fireplace as ashes.

(*d*) A portion of the carbon of the turf usually escapes combustion, and settles in the chimney-flue as soot.

The most important of these changes are the first two, which are attended by the development of heat, upon which the value of the turf as a fuel mainly depends.

To be able to compare the values of different fuel substances with one another, it is necessary to have some method for expressing the amount of heat derivable from a given weight of fuel in terms of a standard unit. The *Absolute Heat Effect* or *Calorific Power* of a fuel is the amount of heat generated by the complete combustion of one gramme of the substance measured in terms of the number of grammes of water which the heat evolved can raise from 0° to 1° C.

According to Favre and Silbermann, the absolute calorific power of carbon (charcoal) is 8080 and of hydrogen 34462 heat units or calories; and if we assume that the absolute calorific power of a compound containing carbon and hydrogen is the sum of the calorific powers of its constituents, and is independent of the manner in which these constituents are united, it will be possible by using the above data to calculate the calorific power of any sample of turf whose percentage composition has been obtained by analysis.

As an illustration of the method let us perform this calculation for the ash-free turf, the composition of which is carbon 60, hydrogen 6, oxygen 32, and nitrogen 2 per cent. That portion of the hydrogen of the turf which is in excess of the quantity of hydrogen required to combine with the 32 per cent. of oxygen in the turf, is called the "free hydrogen." The carbon and "free hydrogen" alone contribute to the evolution of heat. Now, since eight parts by weight of oxygen combine with one of hydrogen to form water, the quantity of "free hydrogen" in the above-mentioned sample of turf will be six minus four, or two parts per hundred of turf. The absolute calorific power will therefore be

$$\frac{60 \times 8080 + 2 \times 34462}{100} = 5537 \text{ calories.}$$

The calorific power thus calculated agrees approximately with that got by direct measurement in a calorimeter, in which a given weight of the turf is burned with a substance capable of affording oxygen in a closed metallic vessel surrounded with a known weight of water, the increase in whose temperature is noted; but, owing to neglecting the heat of formation of the substances of which turf is composed, the agreement is only approximate.

Another less exact but more rapid process for determining the absolute calorific power of the fuel is due to Berthier. In this method the approximately true assumption, that equivalent weights of carbon (3) and hydrogen (1) by union with oxygen evolve the same amounts of heat, is made. In other words, the heat produced by the combination of eight parts of oxygen with bodies consisting of pure carbon, pure hydrogen, or a compound of carbon and hydrogen, is the same. If we weigh, therefore, the amount of lead which is separated from lead oxide by the action of one gramme of turf on it, this will be a measure of the amount of carbon and free hydrogen in the turf, and the absolute calorific power will be got by multiplying the number of grammes of reduced lead obtained in the experiment by 234.2.

The absolute calorific power of a fuel depends on the percentages of ash and water in it. Thus, a sample of turf which contains 30 per cent. of water and 10 per cent. of ash, having a calorific power of 3,700 calories, may have in the anhydrous state free from ash a calorific power of 6,500 calories.

In the following table we give for purposes of comparison the calorific powers of Bog of Allen turf, wood, coal, and anthracite:—

FUEL.	Percentage of		Absolute Calorific Power calculated for Anhydrous Fuel.
	Water.	Ash.	
Bog of Allen Turf, ..	25	7·9	5521
Wood (dry), ...	0	1	4040
Wigan Coal, ...	4·8	1·75	8239
Anthracite, ...	3	2	8740

The amount of heat derivable from a ton of turf can be neither increased nor diminished by any mechanical process of treatment, depending as it does solely on the chemical composition of the turf. On the other hand, the heat derivable from unit volume of turf—the so-called *Specific Calorific Power*—or the calorific power of unit volume of fuel, increases for the same variety of turf with the amount of condensation which the turf experiences in its manufacture. In this manner the specific calorific power of machine-turf or of press-turf may be very much greater than that of ordinary turf from the same bog, although the absolute calorific power may be the same for the different samples. In actual practice it is never possible to utilize the total energy of turf. The heat utilizable from a fire will depend on the form of the grate and the method adopted for stoking the fire. It is easier to approach the ideal conditions necessary for the complete utilization of the generated heat in the case of dense machine turf than in the case of ordinary turf. This has led to the introduction of another method of measuring heat—the economic method.

The *Economic Calorific Power* is expressed in terms of the number of pounds of water which can be raised from 0° C. to 100° C. and converted into steam at the latter temperature by the heat produced in the combustion of one pound of the turf under the best conditions realizable in practice. It varies from two-thirds to three-fourths of the absolute calorific power. The average economic heating effects of ordinary fuel substances are—

Coal, ...	6·5 lb.
Lignite, ...	4·5 lb.
Wood, ...	3·5 lb.
Turf, ...	3·5 lb.
Machine turf, ...	4·8 lb.

From the foregoing table we see that, although the absolute calorific powers of ordinary turf and of machine turf from the same bog are identical, the economic calorific power of the machine-turf is higher than that of the ordinary turf.

In some factories, where high temperatures are required, the values of different varieties of fuel are expressed in terms of the maximum temperatures attainable by their combustion.

The *Pyrometric Heat Effect* of a fuel is the maximum temperature attainable by its combustion under fixed conditions. It is lowered by increase in the percentage of ash, and still more by increase in the percentage of water. Thus good, anhydrous, ash-free turf may, by increases in the percentages of ash and water to

10 and 30 respectively, have the pyrometric heat effect lowered from 2210°C. to 1575°C. If the attainment of high temperatures from turf-fuel is absolutely indispensable in a manufacturing operation, the conversion of machine-turf into anhydrous turf may be necessary. Since anhydrous turf rapidly re-absorbs water from the air, the dried material should be stored under cover, and made only so rapidly as it can be utilized. In all other circumstances the manufacture of anhydrous turf by artificial drying is too costly and without other object than the slight saving of freightage in the transport of the material.

General Remarks on Peat-Fuel.

Turf has acquired importance as a fuel only in isolated instances, and in districts in the immediate neighbourhood of bogs, for several reasons, amongst which may be enumerated:—

1. The relatively high cost of transport (due to the difficulty of loading waggons with the maximum weight allowed).
2. The denser forms of turf, such as "hand turf," require too much skilled labour in their preparation.
3. Briquettes, which are a convenient form of the fuel, are made by machinery, which is only too often uncertain in its activity, and naturally, owing to bogs being in desolate districts far from towns, difficult to repair when important parts have been broken.
4. The removal of the large percentage of water, about 90, from crude peat depends so much on the state of the weather that the industry may during wet summers be almost ruined.
5. Much larger store-houses are required for turf, owing to its low calorific power per unit volume, than in the case of dense fuel, such as coal.

2. *The Cutting of Turf in Ireland.*

After the "stripping" of the turf, by which operation is understood the removal of the upper or "sphagnum layer" from the surface of the peat deposit, the Irish turf-cutter proceeds according to either of two methods—that of the "breast slane," and that of the "wing slane," called partly after the form of spade or "slane" employed, and partly after the position of the slane relative to the labourer when the latter is in the act of cutting. A man cutting turf with a "breast slane" stands in a trench in front of the turf-bank, and cuts the sods by horizontal strokes of the slane, another worker cutting the sods vertically. The sods are then thrown on to the bank, where they are "spread." Two men can cut and spread about sixteen "boxes" of turf in a day. In the "wing slane" method the turf is cut to the required depth on two sides by one vertical stroke, and the lower end of the sod broken by a sudden outward jerk. The sods are removed and spread by another worker. By this method two men can cut and spread about twenty "boxes" of turf in a day.

The methods employed for cutting turf on the Continent are very similar to those used in Ireland—differing only in the shapes of the slanes. In some instances, especially for cutting turf under water, various forms of machines have been employed. One of the best-known of these machines is that of Brosowsky, which may be taken as a type of those most widely used. The important part of this machine is the cutting apparatus, which is in the form of a box, whose front, top, and bottom are open. The sides of the box are formed by knives inclined to the horizontal, and the back is attached to an iron bar, whose sharp lower end acts as a guide to the cutting box. The upper end of the pole is toothed and can be raised or lowered by a winch worked by the hand. When the winch is turned in one direction, the cutting box can be forced down into the bog to a depth of about 20 feet. The prism of peat thus formed is cut at the base by a bottom knife, worked by a chain controlled by levers. By turning the winch in the opposite direction the turf is raised to the surface where it is divided into sods. The cutting apparatus is then shoved through a knife-breadth on a frame, and the operations are repeated. When four prisms have been raised, the whole apparatus is shoved forward through a knife-width on its rollers. The price of a machine cutting to a depth of about 20 feet is £27, and with it, three or four men can in one day cut and spread 12,000 sods, each 1 foot long and with a cross-section of about 24 square inches, that is, about 70 cubic yards, which would weigh, when "air-dry," on the average about ten tons.

Similar machines have been introduced by Müller, Stützke, Weitzmann, and others. A turf-cutting machine, driven by a steam-engine, made by Messrs. Dolberg & Co. of Rostock, is similar to the above.

Peat-Digging Machine at Kilberry.

At Kilberry, near Athy, the peat is cut in large blocks weighing about half a ton by a sort of dredger (Pl. XLVII.), and placed by a crane driven by a steam-engine in small iron cars running on a narrow railway track to the factory. A disadvantage of the machine is that the peat is dug in successive layers, and may therefore be of such variable composition as to interfere seriously with the working of a form-machine. At Kilberry this difficulty was obviated by a fore-treatment of the peat in hydro-extractors and a crushing-machine.

Mecke and Sander's Peat-Digging Machine.

The peat-digging machine of Mecke and Sander rasps with the edges of buckets, moving on an endless chain round pulleys, the whole face of the turf-bank from below upwards. On passing round the upper pulley, the buckets are automatically emptied, and the peat falls into a mixing apparatus which consists of two screws rotating in opposite directions in a cylinder. From the mouthpiece of the mixing-cylinder the peat is conveyed on boards moved by endless chains to an apparatus which distributes it over the surface of the bog. The machine works well when the peat is poor in fibre, and contains few stones or roots; and it gives turf of a uniform character (the buckets scraping portions from the whole face of the bank which can extend through the entire depth of the bog).

Attempts to obtain turf rapidly by ploughing the surface of the bog have been made, but were unsuccessful.

The peat-barge method of Hodges, in which the peat was excavated from the bog by screws projecting from a barge floating on the water in the trench, drawn up into the body of the barge, and delivered from there on to the specially prepared surface at the side, was found of great use for cutting canals through bogs.

3. *Drying or "Saving" Turf.*

After cutting, the wet sods are laid side by side on a dry portion of the bog and occasionally turned, so as to expose all the sides equally to the sun and rain. In about a week or ten days, according to the state of the weather, the sods are ready to be "footed." The operation of "footing" consists of placing the sods on their ends in groups of five or six, so that only a small portion of each sod is in contact with the ground. Having been left in the small heaps for about ten days, the turf is then gathered into larger heaps called "clamps," from which at the end of a fortnight it is drawn into still larger clamps, where it remains until the farmer can remove it from the bog.

The usual method of drying turf on the Continent is like that just described for Ireland. Occasionally it happens that the surface of the bog is too wet to allow of the rapid drying of the turf. In this case various methods are employed to overcome the difficulty. In Bavaria and Finland, instead of "footing" the turf, about thirty or forty sods are piled in pairs round a pole 7 feet high, which is firmly fixed in the bog. In Carinthia, the sods are stuck on short pointed stakes supported horizontally by a stout vertical pole. Each pole is capable of supporting simultaneously one hundred sods, which in fine weather will be "air-dry" in a week. In Sweden, the turf is dried on hurdles made of stout poles fixed in the bog, and carrying short cross-arms at regular intervals, on each of which are placed four long laths which serve to support the sods. Each hurdle is 110 yards in length, and can carry about 6000 sods. At Lexington, Kentucky, in the United States, the action of the air in drying the peat was assisted by absorbing portion of the excess of moisture by means of porous bricks, a layer of which covered the drying-ground. The experiments were not successful. Other methods for drying peat—artificial heating, centrifuging, electrosmosis, and "wet pressing"—will be considered later. Owing to the fact, well known to turf-cutters, that undried peat loses more material in wet weather than that which has been partially dried before the rain began, it is advisable to dry the peat as quickly as possible.

In Ireland the turf is usually dried close to the surface of the bog, which, being often wet, saturates the layer of air in contact with it with moisture.

The turf is sold by measure—the "creel" or load costing about 4*s*. On the Continent it is sold in some places by measure and in others by weight, the price varying from 5*s*. to 8*s*. per ton for "air-dried" turf. When sold by the measure, the buyer is liable to be supplied with light surface turf whose specific gravity may be as low as 0·2, of little calorific value, instead of good heavy mould-turf whose specific gravity may be as high as 1, of high calorific power. On the other hand, when sold by the weight, the buyer may be deceived by a large portion of that weight being due to an excessively high amount of ash, or to a higher percentage of water than that which is usually present (20 to 25 per cent.) in good "air-dried" turf.

Defects of Turf.

The principal defects in the turf at present sold in Ireland are want of density, want of consistency, and high percentage of water. The low density of turf, on the average 0·6, increases the cost of transport and storage; and the percentage of water, occasionally as high as 30, decreases the calorific value of the fuel. These, combined with the defective methods of combustion generally employed, have confined the use of turf as a fuel to the immediate neighbourhood of the bogs. With better methods of preparation, better forms of fire-place, and a rationally developed canal system for the transport of the turf, its use could be extended over a large portion of the country.

The present methods for cutting and saving turf in Ireland are almost identical with those described in "Boate's Natural History of Ireland" (published 1652), as the methods commonly followed during the seventeenth century, for the preparation of turf, which was, at the time, the chief fuel of the country for domestic purposes.

4. *Hand-Turf.*

In some of the Irish bogs the consistency of the peat is so diminished by the deficiency or unequal distribution of its fibrous matter, that the turf cannot be cut into sods which will retain their form when dry. Such peat is dug out of the bog and placed on a flat surface surrounded by boards, where it is well mixed with addition of water. After some days' drying it is cut into sods of the required size, and the "saving" is then finished by turning them over and "clamping," when sufficiently dry. The turf got by this method is much denser, but costs about 20 per cent. more, than that just described.

Amongst other methods which have been used on the Continent from time to time for the preparation of *hand-turf*, one of the oldest is that of Challeton, which was worked at Montauger, near Corbeil, about 1856.

Challeton's Process.—The peat was dug under water by means of long shovels, and brought in boats on a narrow canal to the factory, where it was thrown into a large cistern containing water. It was next conveyed by a sort of "elevator," consisting of buckets, to the upper story of the building, where, with addition of water, it was ground in a mill to a thin mash, and separated from coarse particles, such as roots, by passage through a metallic sieve. As the peat contained an abnormally high percentage of ash, an attempt was made to diminish this percentage by passing the mash through a series of sand-traps. During these operations, it reached the ground-floor of the factory, and was again conveyed by buckets to the upper story, from which it was discharged through inclined channels into the drying-basins. The latter consisted of rectangular pits 15 feet long, 10 feet broad, and 1 foot deep, with porous bottoms, through which the water could soak away from the turf. • After remaining for some days in the pits, the turf was formed into sods and dried in the air. The density of the turf, which, notwithstanding the method of preparation, still contained a considerable percentage of ash, was 1·143, and the percentage of water in it varied from 12 to 15.

A disadvantage of the process is the large space required for the drying pits, whose number, even with the moderate yearly output of 1250 tons, at Montauger, amounted to upwards of 800. Similar processes were employed at St. Jean in Switzerland, and at Langenberg, near Stettin, in Germany.

Recently, in Russia, a process was introduced by Galecki, which resembles closely that of Challeton in its more important points, but is more indirect in arriving at the same results. In Germany and Denmark the mixing of the peat for the preparation of "hand-turf" is now usually accomplished by specially constructed machines, two of which will be described here.

Heinen's Hand-Turf Machine.—The "hand-turf" machine made by Heinen of Varel consists of three horizontal, rapidly rotating spirals which are surrounded by cylinders (fig. 1), and surmounted at one end by a "hopper" and mixing apparatus.

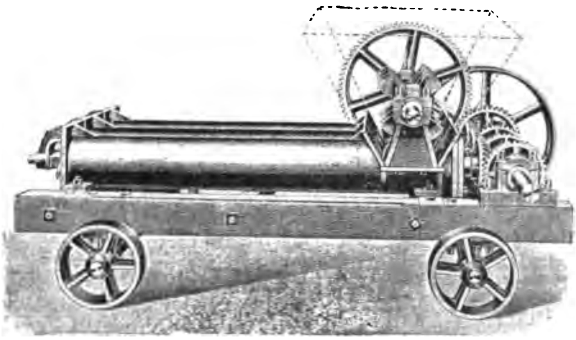

FIG. 1.—Heinen's "Hand-Turf" Machine.

The peat, which passes through the hopper into the cylinders, can be delivered directly on to the field or into cars for transport to the drying-ground when the latter is, as often happens, at a distance from the trench. By means of a frame supported on four wheels, the machine can be moved over boards placed on the surface of the bog. A machine driven by a 6-h.-p. engine can, in twelve hours, make 36,000 sods, which, air-dried, weigh about 18 tons. The working expenses (wages to labourers, fuel and oil for locomotive) are 4*s*. per ton of turf, for which a selling price of 10*s*. can occasionally be obtained.

Similar machines have been constructed by Cohen and Moritz in Hanover, by Müller in Prague, by Beeck in Oldenburg, and by others.

If the amount of turf required per year be not large, the larger forms of machines driven by steam-engines will be too expensive, and in such cases a smaller machine, worked by a horse, may be found sufficient.

Ingermann's Hand-Turf Machine consists of a rectangular wooden box lined with tin, in which a vertical axle rotates. On the axle are fixed seven curved knives, which can pass, with a cutting motion, iron ribs fixed horizontally in the box. One of the four sides of the box is movable, while the opposite side is in part replaced by a small, round box in connexion with the larger, and in which sharp cast-iron plates rotate round another vertical axle in the opposite direction to that in which the main axle rotates. When the peat has been sufficiently divided, and formed into a thin mash by the addition of water, an opening in the side is uncovered, and the contents are discharged into a smaller box, from which they are emptied into a *modelling barrow*, which places the peat on the drying ground in the form of regular sods. With Ingermann's machine five men and one horse can form and spread about 1600 sods daily.

In Denmark, the mixing machines are made of wooden boxes, with rapidly rotating axles carrying knives and screws, and the mixed peat is moulded in frames. About 60,000 tons of "hand-turf" are "saved" yearly in Denmark at an average cost of 4*s*. 6*d*. per ton.

Owing to the large quantity of water in "hand-turf" in the crude state, its drying is very slow, and often in unfavourable weather there is a considerable loss of material. Moreover, the cutting of the turf cannot be continued so far into the summer as in the case of fibrous turf. For these and other reasons attempts have been made, during past years, to obtain more expeditiously from peat a turf which will have the high density and good calorific power of "hand-turf." Amongst these attempts the oldest are those known as "*press methods*."

5. *Press-Turf.*

There are two general methods, which differ only in detail, for obtaining press-turf: in the first the peat is pressed while wet, and in the second while partially or completely dried.

One of the first attempts to compress wet peat was made by Pernitzsch in 1821; and eighteen years later a rude timber press for this purpose was constructed near Hawick by Todd. Shortly afterwards similar but more elaborate machines were introduced by Slight and Lord Willoughby d'Eresby; but the first which was worked on a comparatively large scale was that which was employed in 1844 by C. W. Williams, at Cappoge in the Bog of Allen.

Williams' Wet Press Process.

The fibre of the wet peat was first broken up as completely as possible, and the peat-mash enclosed in cloths was subjected to powerful hydraulic pressure for a considerable time, until its volume was only one-third of that which it had been originally. The press-cake, thus got, was cut into sods still containing from 70 to 80 per cent. of water, which were afterwards dried in the air. It has been stated that the turf was sold at 5*s*. per ton.

The process was too troublesome and expensive to be remunerative. It requires immense and long-continued pressure to lower the percentage of water in undried peat so much as 40. Other disadvantages under which the process laboured were the loss of the finer and better particles pressed with the water through the cloth, the clogging of the cloth by the peat-mould, the smallness of the daily yield from the press, and the occasional expansion of the compressed turf, due to its elasticity, after the removal of the pressure.

Koch and Mannhardt's Wet Press Process.

In Bavaria, the process of Koch and Mannhardt was as unsuccessful as that of Williams in Ireland. In it the peat was led on cloths between large cylindrical roller-sieves, into which the water was forced. Two or three of the thin bands of peat thus obtained were pressed together into one thick band, which was then cut into sods. This method, as well as a similar one patented by Stone, suffered from nearly all the disadvantages of that of Williams.

Schenck's Wet Press Process.

The peat was mixed in the funnel-shaped vessel *A* (fig. 2), by knives rotating round a vertical axis, and was discharged from the opening *b*. The peat-band when passing *c* became subjected to the pressure of the rollers B_1C_1, B_2C_2, &c. The compressed bands of peat which passed through were cut into rectangular sods and dried in the air. The disadvantages of the method, which is no longer used, were similar to those mentioned above.

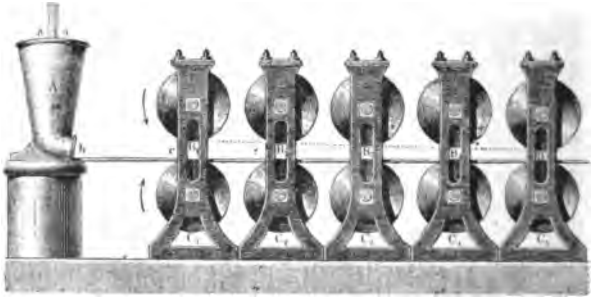

Fig. 2.—Schenck's Wet Press Machine.

Closely allied to the wet press processes are those in which centrifugal force is used to press the wet peat. Amongst the most important of the centrifugal presses is that of Hébert, which has long since become more an ingenious curiosity than a practical machine.

Hébert's Centrifugal Press.

The peat was placed in a cylindrical sieve *aa* (fig. 3), which could be set in rapid rotation by the vertical axle *e* and the shaft *g*, by means of the wheels *c* and *d*, and the outer cylinder *a′a′* was then closed. Concentric with the metallic sieve was a fixed cylinder *i*, which was pierced with several holes through which hot gases could be passed from the tube *k'*. The tube *k'* was closed by a sliding shutter at *t*, and by rapid rotation of the vertical axle, the peat was pressed firmly against the sieve, through which the water passed into the outer cylinder *a'a'*, and from there escaped by the tap *w*. When the water ceased to flow from *w*, the tap was closed, the shutter *t* opened and the combustible gases, which enter through *k'*, ignited. When the rotation of *aa* was continued, the hot gases passing through the compressed peat dried it and, charged with moisture, passed out of the machine through the tube *m*, which was connected with a flue.

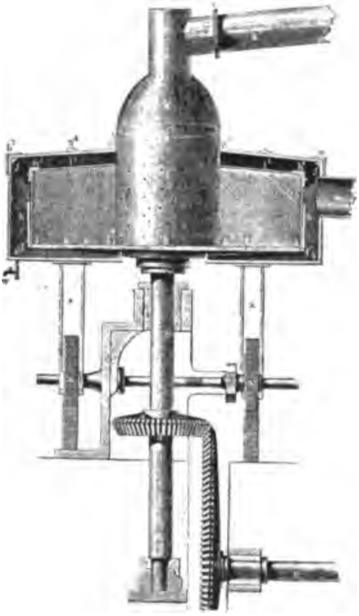

FIG. 3.—Hébert's Centrifugal Turf Press Machine.

The method was ingenious, but, at the same time, impracticable, owing to the ease with which the sieve became clogged, and the difficulty of charging and emptying the machine.

A centrifugal process, patented in England by Gwynne, does not appear to have been used in any factory.

Dry Press Process.

The older processes employed in Ireland for the condensation of turf belong, with the exception of that of Williams already described, to the class known as "dry press." Gwynne's *Dry Press Process* is the oldest of the "dry press" methods used in this country, and seems to have been tried on a small scale at Kilberry, near Athy, about 1855.

The air-dried turf was raised in boxes on an endless chain to the top of the factory, and delivered into a funnel connected with a series of cylinders heated by steam, from which it emerged as a dry powder. It then passed at a temperature of about 80° C. into a press-machine. At this temperature bituminous and tarry matters were said to have been developed in sufficient quantity to bind into a coherent mass the turf shot from the revolving form-table of an excentric press on to an endless band. In the table there were twelve form-boxes, each of which could be brought, in turn, under the piston which exerted the pressure. The estimated output was 240 tons weekly; but, owing to the high temperature and self-heating of the machine, frequent stoppages were necessary, and these, combined with the ease with which the parts of the expensive machinery broke, led to the abandoning of the process. The press-turf was hard and of about the same density as coal. It contained 9 per cent. of water, 3·8 per cent. of ash, and left, when heated in a crucible, 36 per cent. of charcoal.

On the Haspel bog, near Munich, a process very similar to Gwynne's was carried on under the direction of Exter in the middle of the nineteenth century.

Exter's Dry Press Process.

The surface of the well-drained bog was ploughed and harrowed a few times, until the mould was dry. The latter was then brought to the factory in small waggons, running on parallel rails. After passing through a sieve, the powdered, "air-dried" turf was moved slowly by rotating screws over hollow tin floors, arranged in a zigzag manner over one another, and heated by steam to a temperature of about 50° C. On escaping from the lowest of these hot floors, the turf-mould, still containing about 10 per cent. of water, passed through a funnel into a strong excentric press which formed it into bands of press-turf. Variations in the resistance of the peat towards the blow of the piston, which was always of the same length, led to frequent breakage of the machinery and, therefore, to disorganization in the manufacture of the turf, which was finally abandoned.

Sligo Process.

In 1863, a method known as *Buckland's Sieve Turf Process* was employed in connexion with the Creevelea Iron Works, near Sligo.

The peat was thrown into a "hopper" at the top of the machine, from which it fell into a conical metallic sieve, containing holes $\frac{1}{8}$-inch in diameter, through which the peat was forced by a rotating vertical screw. The coarser portions (roots and stones) of the peat fell into a funnel at the bottom, and were removed at the end of the day. The sifted peat passed into a drying-chamber heated by steam; and the partially dehydrated powder was carried on an endless band to a sort of brick-machine, which converted the powder into "press-peat." Dried slowly, the sods formed a turf almost as hard and dense as coal.

The disadvantages of the process are the clogging of the sieve, the loss of fibre, which is of some value as a fuel, but of greater value as a binding material for the sods, and the employment of artificial drying, which can scarcely, under any conditions, form a portion of a remunerative process in the peat industry.

Both Buckland's process and the modification of it introduced into Germany by Versmann were abandoned after a few years' trial.

Derrylea Process.

The failure of Gwynne's process was attributed to three causes:—

1. The frequent breaking of important parts of the machinery.
2. The high cost of artificial drying.
3. The pressure on the briquettes not being sufficiently long applied.

To overcome these defects of the process, it was proposed by Hodgson, about 1866, at Derrylea, near Portarlington, to simplify the machinery as much as possible, to dry the peat partially in the air and afterwards completely by the hot waste-gases escaping from the engines in the factory, and to modify the press in such a way that the time of application of the pressure could be increased to about one minute.

A strip of the bog, 1200 yards long and 100 yards broad, was separated from the rest by two parallel drains, and the excess of water was removed from it in part by the latter, but chiefly by short, transverse, covered drains, which were cut into the bog to a depth of four feet, every 20 yards. Through the middle of this drained strip was laid an iron railway, on which ran a six-wheeled waggon, 24 feet in length. A trellised iron beam, 6 feet in breadth at the centre, and 1 foot at each end, supported by the waggon, projected at right angles to the railway to a distance of about 50 yards on each side. The surface of the bog was loosened to a depth of 1–2 inches, and converted into a sort of mould by harrows attached to the transverse beam, which was moved, together with its supporting waggon, backwards and forwards over the strip by a 6-h.-p. locomotive. In fine weather the mould formed from the bog-surface was said to contain, a few hours after harrowing, 60 per cent. water and 40 per cent. solid matter. This mould was collected by workmen and carried over the railway to the factory, where the drying was completed by artificial means.

The drying chambers consisted of four rooms, 500 feet long, in each of which were two sheet-iron floors, placed one over the other, and extending the whole length of the room. The walls were made of bricks, and the roof of tiles, which served the double purpose of allowing sufficient ventilation through the grooves, and of preventing too much loss of heat by radiation and conduction. The lower iron floor was supported by earthenware pipes, leaving a small space between it and the base of the chamber; through this narrow space the hot gases from the boiler-fires were led by a large ventilator. The upper iron floor, which was placed 4 feet above the lower, was made of 5 iron boxes, each 500 feet in length and 5 feet 3 inches in breadth, which were heated by leading the steam escaping from the engine through them. By means of several iron rakes, 4 feet apart, supported by endless chains passing round hexagonal drums at each end of the chamber, the mould was moved with a velocity of 1⅔ feet per second along the chamber. On reaching the end of the upper floor, it dropped to the lower floor, to the other end of which it was similarly moved by rakes. The dried mould was carried by an elevator to a floor, placed above the press-machine (fig. 4), into the funnel of which it dropped.

The piston *R*, driven by an eccentric *P*, forced the mould in the form of narrow circular discs through the tube *S*, whose length, 3½ feet, increased the time of application of the pressure to one minute. On emerging from the tube *S*, the compressed turf passed through a long canal to the store-house; and by the time the turf had traversed this canal it was found as a rule that the compressed discs, corresponding to each blow of the piston, had separated. The discs had a thickness of 1⅛ inches and a weight of ½ to ¾ lb. The press produced, every hour, over half a ton of briquettes, which were described as nearly free from water, of about the same density as coal, and of a calorific power varying from 60 to 66 per cent. of that of coal.

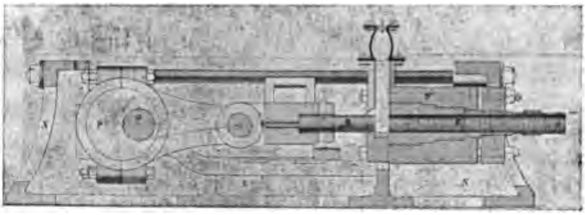

FIG. 4.—Turf Press-Machine, Derrylea, near Portarlington, Queen's Co.

Up to 1868, about 5,000 tons of press-turf had been made at Derrylea; but the method, possessing as it did many of the defects inherent in dry-press processes, was shortly afterwards abandoned.

Within the last few years, the manufacture of turf by dry-press methods has been carried on at Langenberg, near Stettin, and at Ostrach, in Germany, at the Jrinowka Turf Factory in Russia, and at the Griendtsveen Moss-Litter Factory at Rotterdam, in Holland. In these factories the methods employed are similar to those used in the "lignite" industry for the manufacture of briquettes.

The peat is first dried in the air, then artificially in a "Schulze tube" or similar drier, and, finally, is converted into briquettes by a single or double press-machine analogous to that used for the preparation of "lignite" briquettes.

6. *Machine-Turf.*

In the preparation of "machine-turf," advantage is taken of the fact that when well broken and well mixed peat, formed into sods, dries, it undergoes a contraction equal to that which can be brought about by powerful hydraulic pressure applied directly to the peat when first taken from the bog.

Although Williams, in 1844, was one of the first to subject peat to a tearing and mixing process for the manufacture of fuel on a large scale, he afterwards pressed the peat-mash, being probably unaware of the fact that by simply forming it into sods, these, when air-dried, would be as dense as the briquettes turned out by his expensive and cumbrous press.

In 1845, Hasselgren and Dalsland introduced the natural contraction method into Sweden. They broke up, and mixed the peat in a vat; the mash thus got was formed directly into sods.

To Hébert, at Rheims, must be attributed the honour of being the first to use a machine to form sods by the pressure of a rotating screw on the peat-mash. As the machine used for this purpose in 1855 is of historical interest, it will be described here.

Hébert's Form-Machine.

The peat, introduced into the top of the cylinder *A* (fig. 5), was forced through holes in the rectangular base of the vessel by the pressure of a screw rotating round a vertical axis. There were thirteen holes in each of two opposite sides of the rectangular base, so that, simultaneously, twenty-six bands of peat were formed. The peat was caught in the small boxes *dd*, and carried by an endless chain over the octagonal wheels *BB*, The division of the bands into sods was effected by the knives *SS*, which could be raised or lowered in the frame *KK*. The separate sods were then slightly pressed into their boxes by the endless band *ee*, which was kept in motion on a series of small rollers by the friction of the peat. When the sods reached the lower end of the rotating band, they were caught in small hand-boxes *m* by the attendants. The sods were dried in a chamber, heated by hot gases from a charcoal furnace, and had a specific gravity of 1·14.

In Hébert's method, the mixing and forming of the peat were carried out in two distinct machines. The first to carry out both operations in one machine were Weber and Gysser, in 1860, who performed the mixing of the peat by rotating knives in the upper portion of a cylinder and the forming by the pressure of a rotating screw in the lower. Since that time the many modifications of Weber's machine invented may be divided into two classes:—

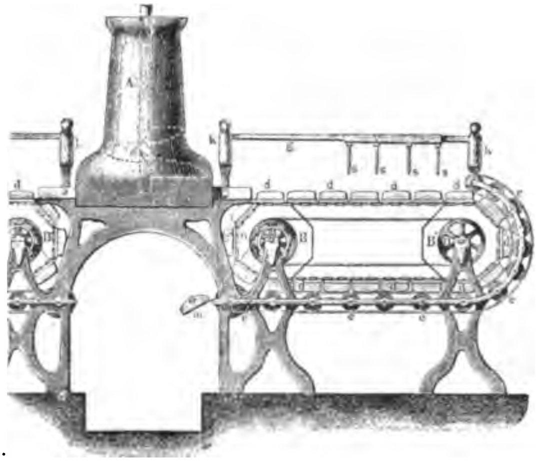

Fig. 5.—Hebert's Turf Form-Machine.

(*a*) Machines with slowly rotating axles.
(*b*) Machines with rapidly rotating axles.

One of the most characteristic examples of the former class, whose axle does not rotate more than fifteen times per minute, is the vertical machine of Schlickeysen.

Schlickeysen's Vertical Machine.

Several broad knives *SS* (fig. 6) are arranged as an interrupted screw on a vertical axle *aaa* in an iron cylinder. The peat placed in the upper part of the cylinder is torn and mixed by the action of the rotating knives, combined with that of the bars *dd*, and forced by the pressure of the screw through the side opening *B* into the forming orifice, which is rectangular in shape and can be kept slightly moistened by a gentle trickling of water through the tubes *r*. The rectangular band of peat is caught on the board *R*, and divided into sods by strokes of a sharp knife. A machine weighing 2 tons, driven by a 10-h.-p. engine, can produce in one day 50,000 sods, which would have a total volume of about 100 cubic yards. The slowly moving knives are, however, unable to cut the fibre properly, and the vertical machines, therefore, which work fairly well with old, non-fibrous peat, become clogged when fed with a younger peat, containing much fibre. Also, in the latter case, the mixing

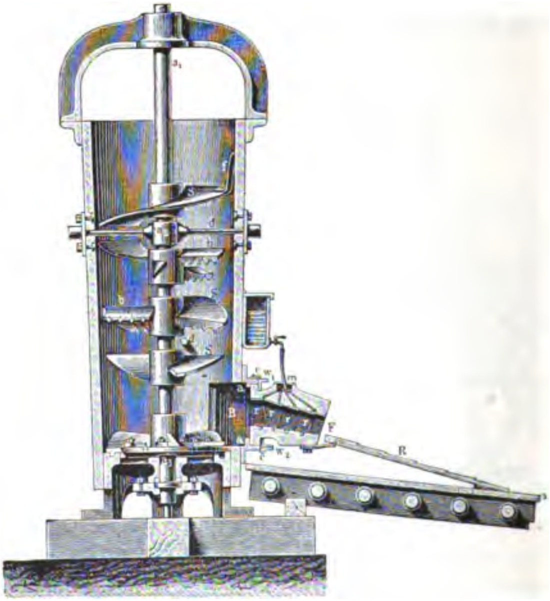

Fig. 6.—Schlickeysen's Vertical Turf Form-Machine.

is insufficient; and these defects, combined with the difficulty of feeding the machine, owing to the height of the mouth of the cylinder above the surface of the bog, have rendered the slowly rotating machines unpopular.

The rapidily rotating machines have all got horizontal axles, and are, therefore, fed more easily than the vertical. In them the cutting and mixing operations are well performed by the rapidly moving knives (75 to 250 revolutions per minute). In some of them the cutting and mixing apparatus is made of knives and screws and in others of screws only, according to the more or less fibrous nature of the peat to be worked.

Heinen's Horizontal Form-Machine.

Several form-machines for various kinds of peat have been constructed by Heinen, of Varel, in Oldenburg. The machines contain two screws rotating in opposite directions in the same cylinder. Some of the machines are fitted with a special cutting and tearing apparatus, rotating round axles and inserted between the funnel and the horizontal cylinder, so that, before reaching the latter, the peat has been well cut and freed from long fibres. The oppositely rotating screws then mix the peat thoroughly and press it through the mouth-piece in two or three bands, according to the machine, and the formed bands are caught on boards moving on small rollers. The peculiar curved shapes of the dividing knives in the form piece, prevent the fibres from adhering to the sharp edges along which they are shoved with a sickle-like motion that quickly cuts them. The upper blade, which projects through a slit on the top of the form-piece, can be unclamped and removed for cleaning or sharpening when necessary. If required, the whole form-piece can be detached from the mixing cylinder.

At Kilberry, near Athy, one of Heinen's machines, without the fore-mixer, has been used to form "electro-peat" mash into sods.

A good form-machine for general use must be able to cut fibre well, and should therefore have sharp knives whose cutting edges form portions of a logarithmic spiral—that is, they are bent in such a manner that the fibres, instead of adhering to the knife and being carried round with it, are cut rapidly as they move round the convex surface. To facilitate the cutting, fixed knives, or counter-knives and screws rotating in the opposite direction, have been employed. The narrower and the longer the mixing cylinder, the more thoroughly will the peat be mixed. In general the knives and screws on modern machines are so similarly arranged that the degree of mixing, on which the efficiency of the machine depends, may be assumed to be directly proportional to the number of axle-rotations per unit volume of the peat. In a good machine, there should be about thirty revolutions of the axle per cubic foot of turf.

As the presence of roots or stones in the peat may easily lead to the breaking of the more fragile portions of the machinery, the latter should be easily detachable, and a stock of spare parts should be kept at hand to replace the broken pieces.

In Sweden and Russia the machines chiefly used for the manufacture of turf are Andersson's, Akermann's, and Aurep's.

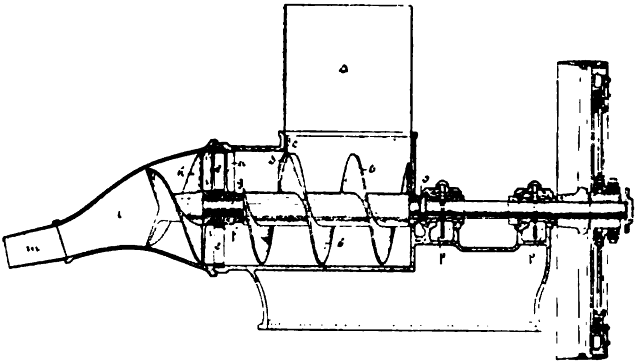

FIG. 7.—Abjorn Andersson's Turf Form-Machine.

Abjorn Andersson's Form-Machine consists of a hopper *A* (fig. 7), through which the peat passes to the screw *bb*, by whose pressure it is forced into the macerating chamber, where a rotating knife *h* and radially fixed knives *ee* cut the peat-fibres. The fixed radial knives, which form a bearing for the rotating axle, are provided on the outer side with sharp edges, which cut the peat against a set of rotating radial knives *ii* attached to the axle. The macerated peat is forced by the screw *k* through the form-piece *m*.

As mentioned above, it can be shown, theoretically, that knives with edges which are straight do not cut so well as those with edges which are curved in the form of a logarithmic spiral.

The machine can be opened easily, and the component parts removed for repair or replacement when necessary. According to the speed of the axle the fibres are cut into parts varying from $\frac{1}{8}$ to $\frac{1}{4}$ inch in length. A machine completely furnished with knives and screws weighs about 3 tons, and, together with an elevator for the peat and a roll-board, costs about £100.

The machines made by Akermann, Anrep, Cegielski, Clayton and Howlett, Dolberg, Jähne, Koppel, Lucht, Seydel, Stützke, Sugg, and others are more or less similar to those already described.

The mouthpieces are usually made of iron, and occasionally are so shaped that, to facilitate the drying of the sod, they leave its centre hollow. At Kilberry, for example, the sods have a triangular space, and at Coolaney, near Sligo, they had a cylindrical space through the centre.

Blunden's Machine, which was employed for a brief period at Coolaney, for the preparation of turf, consisted of a cylinder with a rotating axle, on which were fixed screw-blades and cutting knives. The characteristic portion of the machine was the mouthpiece, which was formed to deliver continuous tubes of peat. The latter, suspended on wires stretched horizontally in pairs, dried more rapidly than the ordinary machine-turf does.

Unfortunately, owing, it is said, to the high rates charged for the carriage of the turf by the distributing companies, the factory has been for some time closed.

In the experiments made by the Department of Agriculture at Inny Junction, one of Dolberg's machines, driven by a horse, was employed, with success, to demonstrate the manufacture of peat-fuel.

7. *Drying Machine-Turf.*

Freshly formed machine-turf never contains less than 80 per cent. of water, and unfortunately the denser the turf is the more slowly it dries. Light surface-turf dries under cover more rapidly than dense machine-turf; conversely, dry machine-turf re-absorbs water much more slowly than light surface-turf does. For these reasons, in good weather, uncompressed peat dries more rapidly than compressed peat; but in changeable weather the machine-turf dries more rapidly and more completely than the uncompressed peat. While ordinary turf may contain from 25 to 30 per cent. of water, good machine-turf should contain only from 18 to 20 per cent. A difficulty connected with the drying of machine-turf, seldom experienced to the same degree in the case of ordinary turf, is due to the "cracking" of the sods. If freshly formed sods be suddenly exposed to a strong sun, the outer surface, drying rapidly, contracts so much that the sods sometimes split or "crack" and lose their regular shape. The time of drying—usually about four or five weeks on open ground—depends on a variety of circumstances, such as the rate of circulation of the air, the time of the year, and the site of the bog. As a rule, in this country, drying in the open can scarcely be effectively carried on for more than three months of the year. It is, however, the cheapest method of drying the turf, costing only about 1*s*. 6*d*. per ton. Where the area of available drying ground is small, and when the weather is unfavourable, some manufacturers dry the turf on form-boards made of laths, which can be placed in groups of four or five in a frame.

Drying under cover.—One of the simplest forms of drying-sheds is that which was employed many years ago at Kohlfurth, in Silesia. Its walls, formed of laths, allowed the air to circulate freely through the turf, and a cheaply covered roof protected the sods from rain. Round another form of drying-shed, which has been used with success in the "lignite" industry, the turf-cars are moved on parallel rails, and the "form"-boards, taken from the cars, are placed in tiers on a framework made to hold them. When the lower portion of the shed has been filled with turf, a platform is inserted, on which the workmen stand while filling the upper portion.

Including all expenses, the cost of the drying is said to be about 2*s*. per ton; but the expense is by no means excessive in a country like Ireland, where the industry in some years could scarcely be carried on regularly in the absence of such structures.

At Kilberry the drying-sheds (Pl. XLVII., fig. 2) are low structures, roofed with galvanized iron, and protected from the rain on the weather side to within some distance from the ground. The floor of the shed is covered with narrow parallel iron rails on which the turf-cars, each carrying several form-boards, move.

Artificial Drying of Turf.

The oldest method for the artificial drying of turf was the hydraulic press method, which was, in isolated cases, used until a few years ago. Though the percentage of water in peat can be lowered from 80 to 50 per. cent. by a pressure of 100 atmospheres maintained for about twenty minutes, the removal of the residual water by pressure presents almost insuperable difficulties.

It has been held by some that the difficulty of removing the water from peat by pressure is largely due to the slimy colloidal humic substances which are said to surround the particles of turf. These colloids can be precipitated by addition of easily dissociated salts, by the action of an electric current, or by the action of heat, and the excess of water is then more easily expelled.

In 1905 a patent was acquired by Messrs. Lucius and Brüning for the improvement of the process for the mechanical dehydration of peat by the addition to the latter—before the application of the pressure—of ionisable substances such as sulphuric and hydrochloric acids, the sulphate and chloride of sodium, or the sulphate of iron.

By the action of an electric current on crude peat it has been found that the peat is driven towards the anode, and the water towards the cathode. This behaviour of colloids suspended in water was explained in 1897, by Coehn (Zeitschr. f. Elektrochemie, iv., p. 63), who found that colloids suspended in water are charged with negative electricity, and the water in which they are suspended with positive electricity. The application of these results to the dehydration of peat was considered by the Graf von Schwerin (*loc. cit.* ix., p. 739).

To remove one cubic metre of water from peat containing 85 to 90 per cent. of water, only 13 to 15 kilowatt hours are said to be required. That quantity of electricity can be produced by burning one-fifth of the turf thus dehydrated, whereas direct evaporation of the water by heat would require the whole fuel produced.

In the patent of Messrs. Lucius and Brüning (D.R.P. 150069) it is stated that the cataphoric action of the current is increased by the addition of alkaline bodies like the caustic alkalies, slaked lime, ammonia and magnesium hydroxide; or of salts such as sodium sulphate, which can give, on electrolysis, free alkali at the cathode; and in a later patent the same firm describes an arrangement for subjecting the electrolysed peat to pressure between movable electrodes.

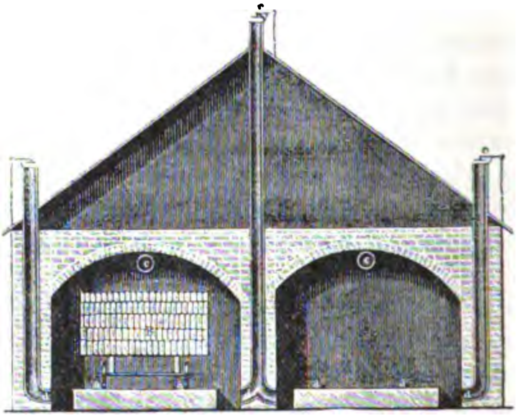

Fig. 8.—Schlagel's House for drying turf by hot gases.

At Kilberry, where an *alternating* electric current has been employed to set free the "latent water" of the peat, the phenomenon of electro-osmosis, above described, cannot assist in the dehydration of the peat.

In Ekenberg's process for the dehydration of peat an attempt is made to coagulate, as it were, the colloids by heating the mass to 180°- 250° C. and then removing the water by pressure.

The more commonly employed methods for artificial drying are:—

(*a*) Heat of waste products from a fire.
(*b*) Radiated heat from pipes containing hot gases.
(*c*) Heat from a current of hot air.

Schlagel's Drying Chamber consists of two vaulted rooms into which the turf could be run on cars moving over iron rails *aa* (fig. 8). The heat of the products of combustion from a fire was utilized as the drying agent. The hot gases were mixed with air until the temperature had fallen below 130° C., and then led into the drying-chamber through the tubes *cc*. The gases pass through the peat, and, getting denser as they grow colder, sink to the bottom of the chamber from which they are drawn into the flues *dd*.

The time required for the drying of the peat is about two days; and the risk of ignition of the dry turf if the temperature rises above 130° C., or if sparks be carried over with the hot gases, is great.

Weber's Drying-Chamber.

In Weber's drying-chamber the gases from the fire did not come into direct contact with the peat. The gases passed through tubes *pp* (fig. 9), and communicated their heat to the air in the space *B*. The hot air passed up through the peat to the top of the room *A*, from which the gases, cooled by contact with the side walls, sank to the bottom, and escaped by the openings *bb* into the flues *DD*.

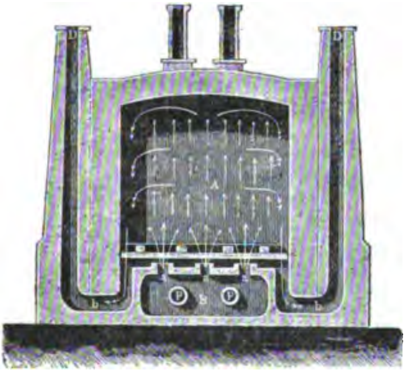

FIG. 9.—Weber's House for drying turf by radiated heat.

At a temperature of 80° C., which was found in practice to be sufficiently low to avoid the danger of ignition of the dried material, the peat was dried in about a week. In this, as in similar chambers, the drying was sometimes ineffective, owing to the current of hot air not always taking the required direction.

When peat dries rapidly, it usually happens that the outer layer contracts and hardens before the moisture can be driven out of the wet core; and peat artificially dried frequently contains as high a percentage of water as that which has been dried on an open surface in the air. To overcome this difficulty, it was proposed by Versmann to heat the peat gradually in a moist atmosphere, and when the sods had been made hot to their cores, to replace the moist current by one of dry air.

Versmann's Drying Process.

The peat was run into the drying chambers on cars moving over iron rails, and by means of a *Davison steam heat-diffuser* a current of air at a temperature of 30° C., saturated with water-vapour, was passed through the chamber for thirty-six hours. A current of air from a *Davison ventilator*, at a temperature of 150° C., was then passed through the peat for six hours, by which time the percentage of water was reduced to about 10. The danger of the fuel in the drying-shed being ignited during the heating of the turf to 150° C. is obviously great.

8. *Electro-Peat.*

At Kilberry, near Athy, in the County of Kildare, during the past two years the Electro-Peat Syndicate, of which the Earl of Mayo was Chairman, has carried out, under the direction of its manager, Captain J. C. Verey, a process (Patent Nos. 37022 and 40559) introduced by Mr. J. B. Bessey, for the manufacture of peat briquettes.

The peat was cut in the neighbouring bog by the "grab" (Pl. XLVII.), and brought to the factory in cars running on a narrow railway. It was then thrown on an endless belt, which projected through the wall of the factory and passed over a funnel placed above the hydro-extractor shown in Pl. XLVI.

A portion of the water was removed by the pressure exerted on the peat in the annular space between the two cylinders, and the partially dehydrated peat passed from the base of the hydro-extractor between the plates of the electrolyser, where it was subjected to the action of a powerful alternating current. The "electrolysed" peat dropped into another hydro-extractor, from which it was carried by buckets on an endless chain to the top of a large slab, where it was crushed by four heavy rollers weighing one ton each. The crushed and partially dehydrated peat-mash next passed into a moulding machine. From the six dies of the latter the peat-blocks were delivered on to a revolving table, provided with a scraper for the removal of the blocks. The briquettes were dried in cars under cover. At a later period the moulding machine was replaced by a Heinen form turf-machine.

Recently the hydro-extracting, kneading, and electrolysing plant has been replaced by a Heinen form-machine of the larger size, in which the mouthpiece has been so made that an alternating electric current can be passed through the peat-bands as they emerge from the machine. The original plant was capable of turning out fifty tons of briquettes per day, and the machinery was driven by electricity generated in a dynamo worked by a steam-engine.

A sample of the electro-peat examined by the writer had a specific gravity of 1·114, contained 16·5 per cent. of water, and 8·5 per cent. of ash.

9. *General Plan for a Turf Factory.*

The manufacture of machine-turf is nearly always associated with that of peat-litter, the upper layers of peat being converted into peat-litter, and the lower into peat-fuel. If situated in the neighbourhood of a good canal, the peat-litter can be sent to its distributing-stations on the canal, which will also serve for the distribution of the peat-fuel.

The manufacture of peat-fuel is, however, best made subsidiary to that of another industry, such as the glass and porcelain industry carried on as near to the bog and to the canal as possible.

If the bog can be drained, the arrangement of the elevator, engine, machine transport railway, drying-ground, and store-houses, given in fig. 10, for which we are indebted to Messrs. Dolberg & Co., will be found suitable. On the other hand, in a wet bog it may not be possible to obtain the peat without employing digging-machines; and for such bogs the transport of the peat from the digging-machines to the forming-machines is most easily effected by means of shallow boats moving over water. For small factories a machine driven by a horse may be used; but for large factories one driven by a locomotive engine is indispensable.

The transport of the turf over the surface of the bog is effected by cars running on portable railways. Richard Lovell Edgworth claimed to have been the first to invent and use portable railways and carriages in the turf industry. He showed, in 1787, at the residence of Mr. Foster, the Speaker of the Irish House of Commons, models of a carriage and a portable railway invented by him, and in use on his estate at the time. They consisted of a short movable wooden railway, resting on wooden sleepers, and a flat wooden car, which could, when loaded with half a ton, be shoved by a single person. The car rested on two large wheels, grooved on their circumference to fit exactly on convex rails, and two smaller trail-wheels. These cars were afterwards adopted at the Penrhyn slate quarries, and were invented independently but at a later date by Roscoe, who employed them in the reclamation of Chat Moss. The modern cars for the transport of peat are made of iron, and consist of a framework on which the form-boards bearing the peat sods can be placed. An illustration of a turf transport wagon made by Messrs. Stützke is given in Professor Johnson's paper (Econ. Proc. R.D.S., vol. i., p. 34).

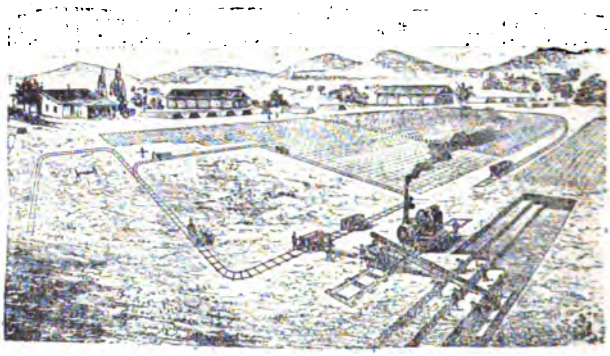

FIG. 10.—Turf Factory on a Dry Bog (Dolberg's System).

Use of Peat Fuel.

Several years ago turf was widely used in Germany in the manufacture of iron and steel. At Neustadt, Josefsthal, Buchsheiden, and Augustfehn large quantities of turf were used for the smelting of iron; and in Ireland, about fourteen miles from Sligo, condensed turf was employed for a time to prepare iron from its ore in a small blast furnace of about twenty-three feet in height. Gradually, owing to cheaper coal, and improvements in the methods of transport, turf was displaced from the iron industry, for which it was not well suited, notwithstanding the fact that the steel got by its means, being free from sulphur, was better than that prepared by the use of coal.

In the glass and porcelain industries turf, and especially turf generator gas, has a much brighter future, as will be pointed out in a later section of this paper.

The advantages possessed by turf for the raising of steam are due in part to the comparative cheapness of the fuel, but chiefly to the life of the boiler, heated by a large turf flame free from corroding gases, being longer than when the more intense and corrosive coal flame is employed. The results obtained by the Inland Navigation Company of Ireland in their experiments on the comparative costs of turf and coal required by their steamer (the Lansdowne) on the Shannon are of sufficient interest to be recalled. The cost of the coal required to drive the steamer for forty-nine hours was £18 (twenty-four tons of coal at 15*s*. per ton), and that of the turf necessary for the same amount of work was £9 12*s*. 7*d*. (fifty-five tons of turf at 3*s*. 6*d*. per ton). At the present day the difference in the costs of the fuel would not be so great.

In Wurtemburg, Baden, Hanover, Bavaria, and Oldenburg, about forty years ago, turf was used on the railways to drive the slower trains (goods trains); but within the past ten years its use has been almost completely abandoned except in one or two places, as in portions of Bavaria where the State continues its use to afford employment to the inhabitants of these poor and desolate districts.

About twenty-five years ago the Great Southern and Western

Railway Company, Ireland, made experiments on the relative costs of coal and turf for firing locomotives and smelting iron, with results which, owing to the low cost of coal at the time, were unfavourable towards the turf. Similar experiments on a smaller scale, made in the electric power station at Sutton, near Dublin, established the fact that as a steam producer for the generation of electricity turf compared favourably with coal. For the latter purpose it would be, however, more economical to convert the turf directly into mixed power gas and with the latter drive the engine. By this method a much larger proportion of the energy of the turf can be utilized.

SECTION II.—THE PEAT DISTILLATION INDUSTRIES.

1. *Turf-Charcoal.*

When turf is heated in the presence of a small quantity of air, the hydrogen and oxygen present are eliminated, and a residue called turf-charcoal is obtained. More than one hundred years ago attempts were made to prepare charcoal from turf, so that this fuel might be made available for use in the processes employed for the extraction of iron from its ores. In 1735, Lange and Zanthier converted turf into charcoal, and still earlier (in 1712) the process was mentioned by Carlowitz in his "Sylvicultura Œconomica."

The methods which have been employed for the charring or coking of turf may be divided into three classes:—

(*a*) Coking by "fire-gases" in heaps or kilns.
(*b*) Coking by heat radiated from the walls of a retort.
(*c*) Coking by superheated steam.

To obtain the maximum amount of charcoal from a given amount of turf, it is necessary to limit, so far as possible, the formation of volatile carbon compounds.

2. *Coking in Heaps.*

A portion of the surface of the bog is drained and levelled. In the centre of this space a pole is inserted, with inflammable material placed at its base, and round this pole concentric layers of turf sods are set so as to form a conical heap of about 80 cubic yards content. A channel is left at the bottom of the heap to facilitate the igniting of the turf. The heap is covered first with bushes and then with a layer of earth, whose thickness gradually decreases from 1 foot at the base to 6 inches at the top. The turf is ignited, and after the burning has well started the central hole at the top of the heap is closed. Small holes are opened at the sides for the admission of the air necessary for the combustion. An experienced workman is required to watch the heap, since occasionally the combustion, when irregular, may produce holes in the external covering. Such holes unless filled immediately with fresh turf and earth may cause serious injury to the heap. At the end of the combustion all the apertures are closed with wet clay, and the contents are cooled slowly for several days before the covering layer of clay is removed. The supply of air to the heap can be further controlled by the erection of a wind-guard, made of boards round the latter. The yield of charcoal varies from 25 to 40 per cent. of the weight of turf burned.

In some districts on the Continent the coking has been performed in pits 1 yard broad and 20 yards long by a method similar to that just described.

In Sweden turf has been coked in kilns. A small fire is started at the bottom of the kiln, and the latter is then filled with turf. A conical heap of turf is made above the surface of the kiln, and when this, owing to the combustion going on below, has sunk to the level of the mouth of the kiln, the turf is covered with flags cemented with clay to cut off the air, and the contents are allowed to cool slowly before the charcoal is removed.

3. *Coking in Furnaces.*

One of the oldest methods for coking turf is that which was introduced by Lange about the middle of the eighteenth century.

Lange's Furnace consisted of two iron cylinders, *D* and *E* (fig. 11), with a conical head *F*, resting on an iron plate *BB*, which was fixed to a rectangular stone base *AA*.

A few iron bars were laid across the square opening *b* in the iron plate *BB*, and the furnace was filled with turf through the opening *f*. A fire was ignited in the vaulted hearth *C*, whose external opening was tightly closed with a well-fitting door. When the turf had been coked, the furnace was again filled and the operations repeated until the furnace was full of glowing coals. The top was then closed and the contents allowed to cool.

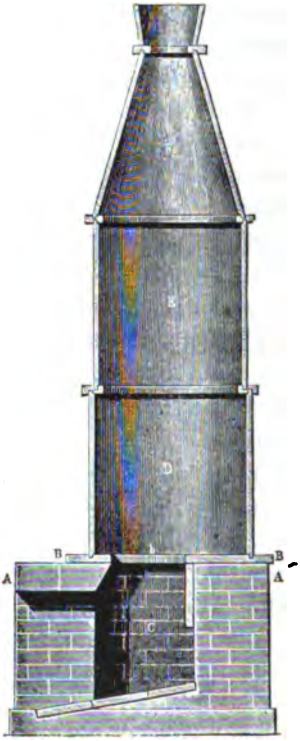

FIG. 11.—Lange's Turf-Charcoal Furnace.

Forty furnaces of this class were worked during the years 1745–1749 at Wernigerode; but as the yield was poor, and the charcoal too porous for general use, the furnaces were shortly afterwards abandoned.

A disadvantage attending the preparation of turf-charcoal in furnaces where the charring is effected by the ignition of the turf at the bottom of the furnace is that the hot, friable coals produced easily crumble away under the pressure exerted by the column of turf resting on them. For this reason in the later forms of furnaces the ignition is started at the top, and the volatile products of combustion are allowed to escape at the base.

Hahnemann's Furnace was filled from the top, and after ignition had started there, it was closed air-tight by an iron plate, through whose centre an iron tube passed to the base of the furnace. During the coking the volatile products escaped through small holes in the lower end of the central iron tube, and, owing to the combustion proceeding from above downwards, the charcoal produced was not subjected to the pressure of undecomposed turf.

Wagenmann's Furnace aimed at still further reducing the pressure on the hot charcoal by means of a gradual contraction in the furnace-shaft from above downwards.

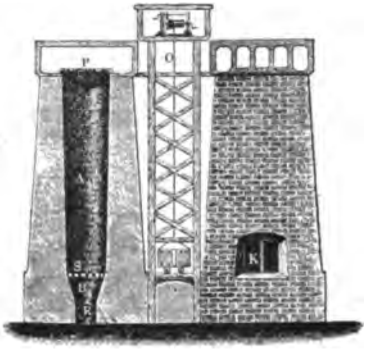

FIG. 12.—Wagenmann's Turf-Charcoal Furnace.

The turf was raised to the mouth *P* (fig. 12) of the furnace *A* by the elevator *O*, and the hot gases were removed through the tube *R* by means of a suction-pump, which also served to regulate the entrance of the air through the draught-holes in the plate *P* which closed the orifice of the furnace. The grate *S* served to prevent the charcoal from closing the tube *R*. The charcoal was removed from the furnace through the opening *K*, which was closed air-tight during the combustion.

In Schenck's improvement of this furnace the coking was effected by the combustion of turf-gas, which was admitted through a tube in the orifice of the furnace.

Roger's Furnace.

At Derrymullen, in the Bog of Allen, about the middle of the last century, considerable quantities of powdered turf-charcoal were made and sold to farmers for use as an admixture with manure.

The sides of the prismatic drying-shed *HH* (fig. 13) were made of boards arranged, like Venetian blinds, in such a manner that the spaces between the individual boards could be enlarged or decreased as required. Through the centre of the floor passed a stone-work canal, *BB*, whose bottom and side-walls were protected by iron plates. Parallel iron rails were fixed on the sides of this canal to facilitate the introduction of the pyramidal furnaces *AA* which were filled with the dry turf to be coked. From the apex of each furnace a metallic tube led to the top of the drying-shed. The heat radiated from the furnaces and their flues dried the turf with which the upper portion of the shed was filled. To minimize the danger of fire in the shed, the furnaces and flues *DD* were protected by enveloping iron tubes *CC*. The turf in the pyramidal furnaces was ignited by utilizing for this purpose the canal which passed under their sieve-like bottoms; and when smoke ceased to pass from the flues, the chimneys were closed by plugs, the canal flooded with water to the level of the furnace-bottoms, and the contents were thus cooled in the absence of air.

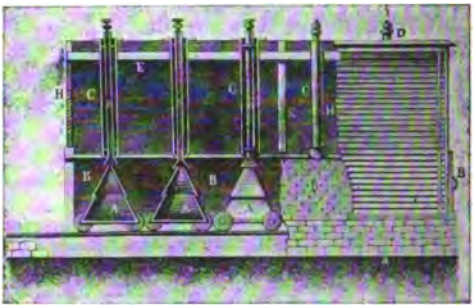

Fig. 13.—Roger's Turf-Charcoal Furnace, Derrymullen, in Bog of Allen.

Each furnace could coke about one quarter of a ton of turf in five hours, and yielded about one-sixteenth of a ton of charcoal in the same time. At the factory, which was owned by the British Amelioration Society, the charcoal was prepared at a cost of 18*s.* per ton and sold for £1 15*s.* per ton.

4. *Coking in Retorts.*

The preparation of turf-charcoal in retorts is usually combined with the utilization of the by-products; but as the second portion of the process will be described more fully later on, only the preparation of the charcoal will be considered here.

Of the two classes of retorts in use—the vertical and the horizontal—the horizontal being the more important, only one example of the vertical retorts will be described.

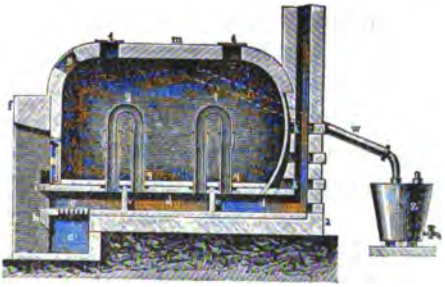

Fig. 14.—Lottmann's Turf Distillation Retort.

Lottmann's Retort consisted of a somewhat elliptically shaped double-walled chamber, which was heated by the hot gases from the fire *c* (fig. 14), which passed through the canal *d*, under the floor of the chamber and through the tubes *qq* which projected into the centre of the room, before finally escaping from the chimney *k*. Close to the central fire *a*, were two side fires, the hot gases from which, after passing through the narrow space between the walls of the chamber, escaped through the flue.

The furnace was filled with turf through the door *b*, and the openings *tt* at the top. The volatile products formed by the action of the heat on the turf passed through two tubes in the sides of the vaulted roof to a condenser.

It was found necessary to burn about 45 tons of turf in the fires in order to convert 100 tons of turf into charcoal (40 tons).

Horizontal Retort of Thenius.

The retorts in use at Bührmoos for the manufacture of turf-charcoal and turf-tar were constructed according to the plans of Thenius. The retorts consist of rectangular wrought-iron vessels provided with lids at one end through which the turf can be introduced and fitted at the other end with a side-tube through which the volatilized substances pass to the condenser. In the rectangular retort near the origin of the side-tube a sort of sieve is inserted, whose object is to prevent pieces of charcoal from falling into the side-tube; and to prevent explosions during the re-filling of the retort, a movable shutter is inserted in the side-tube. Wrought-iron is used in the construction of the retorts because it has been found that it withstands the action of the heat better than cast-iron.

From 100 tons of turf (dry), 40 tons of charcoal are obtained. The cost of equipping a factory provided with thirty-six of these retorts capable of coking 13 tons of turf daily has been estimated at £9000.

Ekelund's retort is divided into two compartments, in the upper of which the turf is dried by the hot gases evolved during the coking, which is accomplished in the lower. The special provision of drying-houses is unnecessary in this process, which met with a very favourable reception in Sweden, but seems nevertheless to have been abandoned.

Ziegler's retort consists of a vertical cast-iron furnace connected with a condenser, and so arranged that the solutions of the by-products—ammonium sulphate and calcium acetate—can be concentrated by the heat contained in the waste products from the combustion. The inflammable gas which is given off during the coking can be employed to char the turf. In 1901, the Russian Government started at Redkino a factory provided with eight Ziegler retorts, but experienced considerable difficulty in the utilization of the turf-gas produced.

Schöning's Turf-Charcoal Process.

At Stamsund, in Norway, turf was coked by pressing it to one-fifth of its original volume between hot iron plates or rollers. The initial difficulties which were encountered led to the alteration of the original process. In the improved process, subsequently adopted, the turf was broken up, dried at the high temperature of 200°C., and after a slight charring transferred to hot moulds, in which it was subjected to a pressure (hydraulic) of 200 atmospheres.

Jebsen's Electrical Coking Process.

To diminish the waste of heat which takes place when a retort filled with turf is acted upon externally by fire-gases, partly owing to loss by radiation and convection, but chiefly owing to the low thermal conductivity of turf, an electrical method for heating the turf has been invented by Jebsen. The turf is placed in a retort, whose walls are covered with asbestos or other non-conducting material, and is heated to 450° C. by electric currents, flowing through insulated coils at the centre, and round the internal surface of the retort-walls. Very little attention is required during the heating of the turf, which is quickly and thoroughly accomplished. In countries like Norway, which are richly endowed with water-power, the method may be made remunerative.

Coking by Super-heated Steam.

The method patented by Vignoles for charring turf by the action on it of super-heated steam, although of little practical interest, was of an original nature. On each side of the boiler, by means of which the steam required to coke the turf was generated, there were six coking cylinders, whose walls were surrounded by passages through which the hot gases from the fire circulated. The steam from the boiler was first led through a strongly heated spiral tube and afterwards through the first of the coking cylinders, from which it passed to the second heated spiral tube and the second coking cylinder, and so on for the whole series. The coke was emptied into iron boxes which were provided with tightly fitting lids, and placed directly under the coking cylinder. The method, though ingenious, could not be made remunerative in practice.

5. *Properties of Turf-Charcoal.*

The properties of turf-charcoal vary with those of the turf from which it has been prepared, and to some extent with the method of preparation employed. A light surface-turf gives a light, friable, and inflammable charcoal, which contains very little ash; a dense black turf gives a much denser variety of charcoal. In selecting turf for the preparation of charcoal, attention should be paid to the three following important particulars:—

(*a*) Density of the turf, upon which depends the density of the charcoal.

(*b*) Percentage of water in the turf, which, if high, will decrease the percentage of charcoal obtainable from it both by decreasing the percentage of the anhydrous material in the turf and by reacting with the hot charcoal to form a volatile carbon compound (CO).

(*c*) Percentage of ash in the turf, which may be so high as to render the charcoal got from it useless for most technical purposes. As a rule, it may be assumed that the percentage of ash in turf-charcoal is about two and a half times that in the turf from which it has been prepared: more exactly, it is 100 s/p where s is the percentage of ash in the turf, and p is the percentage of charcoal obtainable from it.

The temperature, 2380° C., attainable by burning turf-charcoal is as high as that which can be reached with the best wood-charcoal. The calorific powers of the two kinds of charcoal are practically identical.

Many years ago Derust showed that turf-charcoal could replace with advantage wood-charcoal in the manufacture of gunpowder. It can also be used for the absorption of noxious gases and the decolourisation of liquids such as impure solutions of sugar. For the purification of water, and admixture with manure to absorb the valuable gases given off during its decomposition, turf-charcoal has a small but growing demand.

The coke got from turf is in some respects superior to that from coal, but in others distinctly inferior. Being almost entirely free from sulphur and phosphorus, turf-coke when used in the smelting of iron gives a much purer metal than that got by means of ordinary coke. Although it has been used in small blast-furnaces, its lightness and inability to withstand pressure must prevent its being employed in high furnaces, for which a denser and harder fuel, such as coal, is better adapted.

Of the many interesting experiments which have been made with turf-coke only a few can be here noticed. It was found in a locksmith's forge that two circular pieces of iron, about 1¼ inch in diameter each, were welded together in four minutes when turf-coke was used to heat them, whereas a longer time and larger quantities of fuel were required to perform the same operations when wood-charcoal or smelting coke was employed. Similarly in two hours a file-cutter, with 8 pounds of turf-charcoal, forged 100 files ; and in the same time he was able to forge only 80 files when wood-charcoal was used, notwithstanding the fact that 10 pounds of the fuel were necessary.

The possibility of being able to employ turf-charcoal in many operations, such as the manufacture of calcium carbide (acetylene gas industry), is obvious.

The success of a turf-charcoal factory depends on the available peat being poor in ash and free from sulphur, on the employment of dense machine-turf so that a good coherent coke can be produced, on the collection and utilization of the volatile products, and on the presence in the immediate neighbourhood of the factory of other manufactures, like that of iron, in which the charcoal can be employed.

The average cost of production of one ton of good turf-charcoal is about £1 10*s*., and the price obtainable for the charcoal about £2.

Turfite, or Half-coked Turf.

While good turf-charcoal contains

Carbon,	.. ..	90 per cent.
Hydrogen,	.. ..	2·5 „
Nitrogen,	.. ..	2·5 „
Ash,	.. ..	3·5 „
Moisture,	.. ..	1·5 „

another substance—"turfite," or half-coked turf—which has been placed on the market within recent years contains a much lower percentage (65) of carbon, and higher percentages of hydrogen and oxygen.

Rosendahl's process may be taken as typical of the many recommended at various times for the preparation of this substance.

The turf is heated slowly in iron vessels to a temperature of 250° C; the exit tubes of the vessels are then closed and the temperature kept constant for about seven hours. The tarry products are retained in the turf, and increase the yield of inflammable "turfite" to about 80 per cent. of the anhydrous turf employed. The product has been used in Krupp's works for the smelting of iron with advantage; and experiments made with it in Norway indicated that, under favourable conditions, it may replace coal for the heating of rooms. It should, however, be borne in mind that it is theoretically impossible by any process to increase the absolute calorific value of one ton of turf; as a matter of fact, the heating power of the charcoal is only about two-thirds of the heating power of the amount of turf from which it has been formed.

Utilization of the By-products.

It is customary to divide the by-products formed in the preparation of turf-charcoal into three classes:—

(*a*) Tar.
(*b*) Gas-water.
(*c*) Gases.

In the following these three classes will be considered separately.

Turf Tar.

As early as 1786 Thillage-Platel and Lebon coked turf in retorts to obtain tar and gas, but without much success. The first large turf-distillation factory, whose object was the preparation and purification of turf tar and gas-water, was started in 1849 at Kilberry, near Athy, to work a process, patented by Mr. Reece, which was based on the results of experiments carried out by the latter, in Pelouze's laboratory in Paris, and at Newtown Crommelin, in the County of Antrim.

The following table shows the percentages of tar, gas-water, charcoal, and gas which were obtained by Kane and Sullivan, who examined the process on behalf of the Government, on the distillation of turf derived from various Irish bogs.

SOURCE OF TURF.	Tar.	Gas-water.	Charcoal.	Gas.
Mount Lucas.	2	23·60	37·5	36·90
Bog of Allen, surface, ..	3·58	32·27	39·13	25·02
Bog of Allen, deep, ..	2·77	38·10	32·64	26·49
Ticknevin, surface, ..	2·91	33·63	31·11	32·35
Mountshannon, surface, ..	4·42	38·13	21·87	35·70
Mountshannon, deep, ..	1·46	21·19	18·97	57·75

Two methods of distillation were tried, in the first of which the turf was distilled from a retort closed at one end, and in the second from a retort open at both ends, the turf being heated by a blast introduced at the lower end. If we compare the results obtained by the second method for the surface and deep turf of the Bog of Allen and the deep turf of Mountshannon, given in the following table:—

SOURCE OF TURF.	Tar.	Gas–water.	Ashes.	Gas.
Bog of Allen, surface, ..	2·51	31·68	2·49	63·14
Bog of Allen, deep, ..	2·40	30·66	7·23	59·72
Mountshannon, deep, ..	·2·27	29·82	2·87	65·04

with those just given for the same classes of turf in closed retorts, we shall see that the quantities of tar and gas-water obtained by the two methods do not differ greatly. At Kilberry the second method was selected for the manufacture, probably because there was no demand for charcoal in the neighbourhood, and it seemed better, therefore, to utilize the charcoal produced in the retort as fuel for the distillation of the peat, and for the formation of combustible gas.

The furnace (fig. 15) was filled with turf through a funnel-shaped mouth *B*, which was then closed air-tight, and the combustion was maintained in the retort by blasts of air introduced through pipes *aa* at the base. The volatile products escaped through side-tubes *CC* into a receiver *E* (fig. 15), where the tar and gas-water condensed, and from which they passed through a pipe *V* into a cistern, while the gases passed through a double series of vertical condensation tubes, 25 feet in height, in which further quantities of tar and gas-water were collected. The gases then passed through a series of eight towers *q*, which contained coarse gravel, kept moist by a slow current of water, and were then of sufficient purity to be collected in a gasometer.

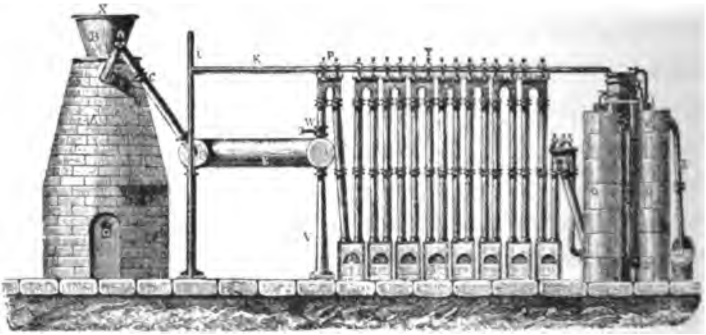

Fig. 15.—Turf Distillation Plant, Kilberry, near Athy, Co. Kildare.

Extraction of Acetic Acid and Ammonia from "Gas-water."

The composition of "gas-water" varies with the nature of the turf from which it has been formed. Fibrous turf gives relatively large quantities of acetic acid and methyl alcohol, with smaller quantities of ammonia and similar bases. On the other hand, dense, lowland turf gives relatively large quantities of ammonia and allied bases, such as aniline, toluidine, and pyridine. Broadly speaking, gas-water may be regarded as a solution in water of methyl alcohol, ammonium acetate, and ammonium butyrate, with small quantities of suspended tar. The first operation to which it is subjected is filtration through vats containing charcoal, to remove the traces of tar. It is next neutralised with milk of lime; and after making it slightly alkaline it is filtered through linen. The "*pyridine residue*" is dried, powdered, and either sold as a disinfectant or worked up for aniline and pyridine by a process which will be described later on.

The clear liquid which passes through the filter contains methyl alcohol, calcium acetate, ammonia, and traces of other substances. The ammonia and methyl alcohol are distilled slowly from a retort and collected with the water, which distils at the same time, in a receiver. As the distillation from the retort proceeds, resinous substances separate, and must be removed from the retort by means of a perforated ladle. Towards the end of the evaporation of the water the solution must be stirred well to prevent the decomposition of the calcium acetate, which separates from the liquid. The removal of the last portions of the water from the solid residue, which consists mainly of *calcium acetate*, is completed at a lower temperature.

The nitrogenous distillate from the lime salts is neutralized with sulphuric acid, filtered from resin and redistilled from a copper boiler. The various fractions, which now come over, are collected separately, dried with quicklime, and redistilled to obtain the purified *methyl alcohol.* The residue in the retort from which the methyl alcohol has been distilled is filtered from resin, and evaporated slowly in a cast-iron boiler until the ammoniacal salt begins to crystallize out. The evaporation is then continued at a lower temperature with constant stirring until the *ammonium sulphate* is quite dry.

Light Petroleum, Lubricating Oil, and Wax.

The most important substances from turf tar are:—Light petroleum, lubricating oil, wax, creosote and asphalt.

The tar is first freed from gas-water by being heated in large open vessels by steam until molten. It is then cooled and the semi-solid tar is removed from the top. By repeating the operations in another vessel, with addition of a little dilute sulphuric acid, the last traces of ammonia are removed. Before distilling the tar it is melted with 2 parts of a 15 per cent. caustic soda solution per 100 of tar.

The tar is distilled slowly from a large cast-iron retort. Light petroleum and water come over first (the receiver being changed when the water has been completely expelled from the retort). The temperature is then raised, and a further quantity of crude petroleum is collected. When the second distillate is about one-tenth of the total amount of tar taken, the contents of the receiver are added to the light petroleum, which has meanwhile been separated from the water on which it floated.

The temperature is still further raised, and in the receiver a crude oil, which now contains paraffin wax, is collected until its weight reaches one-third the weight of the tar taken. The hot, molten contents of the retort are poured into moulds, where they solidify to blocks of *asphalt.* The crude wax oil is placed in vats whose sides are provided with bung-holes at various heights, and stored in a cold cellar for a month until the greater portion of the wax has solidified. The plugs are then removed from the bung-holes, one after the other, from above downwards; the oil is pressed out of the solid wax and added to the crude petroleum. The last portions of the oil (lubricating oil) are removed by cold pressure from the turf wax, which is then melted in boilers, filtered while hot through a woollen cloth, and allowed to cool. After removing the impurities from the bottom of the cake, the latter is melted in a copper boiler; a little caustic soda is added to it, and the mixture is cooled. The cake thus got is cut into smaller ones, which are surrounded with press-cloths and subjected while warm to hydraulic pressure. The wax is then ready for the manufacture of candles.

Before separating the crude petroleum into its constituent fractions—light and heavy petroleum—it is necessary to determine approximately the percentage of creosote and resin acids contained in it. For this purpose 50 c.c of the crude petroleum are placed in a graduated cylinder, and 50 c.c of a strong caustic soda solution

(15° Bé.) are added. The stoppered cylinder is well shaken and then let stand until the oil has separated from the soda solution. From the decrease in the volume of the oil the percentage of creosote and resin acids contained in it can be calculated. The calculated quantity of caustic soda solution necessary for the removal of the creosote is stirred for an hour with 4 cwt. of the oil in a barrel provided with bung-holes in its sides, and then let stand for several hours. The oil is separated from the soda solution of the creosote and resin, transferred to an open vessel lined with lead, and stirred for an hour with 5 parts of strong sulphuric acid per 100 of oil. The waste sulphuric acid from this operation can be poured on slaked lime and sold as manure. The oil is transferred to another vessel, again stirred with 2 parts of caustic soda (15° Bé.) per 100 of oil and distilled from a cast-iron or copper retort. The first portion of the distillate, which is generally yellow in colour, is collected apart. When the distillate becomes colourless, the receiver is changed and the *light petroleum* collected in a barrel until its density rises to 0·83. The receiver is again changed and the *heavy petroleum*, whose average density is 0·85, is next caught. A black residue, consisting of caustic soda and tar, is removed from the retort at the end of the experiment.

Turf Creosote is obtained from the soda residues formed during the purification of the petroleum. The sodium creosotate solution, placed in a vat, is treated with sulphuric acid until the oil ceases to separate. The oily layer is separated from the acid, washed with water, and distilled from a retort with 10 parts of caustic soda (15° Bé.) per 100 of oil until about 70 per cent. of the oil has gone over. (The residue, sodium resinate, in the retort is used for the preparation of lampblack.) The crude creosote is stirred for an hour in a lead-lined vat with 10 per cent. of concentrated sulphuric acid and 0·5 per cent. of potassium bichromate. The oil is next washed with water and heated with caustic soda (10 per cent. 15° Bé.). It is treated twice with dilute sulphuric acid, washed with water, and redistilled. The creosote is separated from insoluble oil by solution in caustic soda and boiling for some time. On adding sulphuric acid to the cold alkaline solution, an oily layer of creosote separates; and when this has been washed with water and redistilled, fairly pure *creosote* collects in the receiver.

The separation of pure creosote from turf-tar being a very troublesome process, it may in most cases be more advantageous to dissolve the crude oil in weak alkali and utilize this alkaline solution as a disinfectant, or convert it into its lime compound by shaking it with finely powdered sifted slaked lime.

Organic bases, like pyridine and aniline, may be extracted by shaking a large quantity of turf-tar with a small quantity of 10 per cent. sulphuric acid. The aqueous solution of the sulphates of the bases is concentrated in a leaden vessel, and filtered from resin. The oily bases are separated from their salts by addition of caustic soda, and are purified by re-dissolving in acid, filtering, and re-separating by caustic soda. The oily bases are dried with caustic potash and distilled.

Tar from mountain-turf contains very little, but that from lowland-turf contains appreciable quantities, of these organic bases.

Lampblack is obtained by burning the dry alkaline tarry residues left in the various operations employed for the preparation of petroleum and creosote from turf-tar, with a limited supply of air in a specially constructed chamber. The soot produced passes through a chimney into a series of rooms on whose walls it is deposited. 100 lb. of the alkaline turf-tar waste give about 30 lb. of lampblack and 40 lb. of crude carbonate of soda. The lampblack can be used for the manufacture of boot-polish or of printers' ink.

6. *Properties and average amounts of the By-Products.*

Methyl alcohol is a colourless volatile liquid, which boils at 66°C., and has a specific gravity of 0·796. It is a good solvent for many organic compounds, and is employed on the one hand as a source of heat, and on the other for the manufacture of dyes and varnishes.

Ammonium sulphate is a colourless crystalline solid, which is readily soluble in water. From it valuable artificial manures may be obtained directly. It can also be readily converted either into free ammonia or other ammoniacal salts, such as the carbonate and alum, which are of considerable importance in commerce.

Calcium acetate is a colourless solid, soluble in water. It gives on destructive distillation acetone, and on distillation with sulphuric acid acetic acid is obtained. The acetic acid can be utilized for the manufacture of pigments, such as "white lead" and "Schweinfurth Green"; of mordants, such as iron acetate; and of various other technically important bodies, such as vinegar.

Light petroleum is a clear, limpid liquid of mild, aromatic odour, and having a specific gravity of about 0·825. In ordinary paraffin-oil lamps it burns with a fine white flame. It can be used either as an illuminant or for the extraction of stains from garments, &c.

Heavy petroleum or *solar oil* is, when first prepared, colourless, but on standing for some time it becomes yellow. Its specific gravity is 0·85. In a suitable lamp it can be burned with a very bright flame, but its chief application in industry is as a lubricator for machinery. By mixing it with tallow, American resin, slaked lime, and "blue resin oil" a valuable car grease can be prepared.

The *lubricating oil* expressed from turf-wax has a density of 0·895. *Wax* got from turf-tar contains about 85 per cent. of carbon. It is very hard, and with addition of about 10 per cent. of commercial stearine can be moulded into candles, which burn with a good bright flame.

Average amounts of the By-Products.

The quantities of the more important by-products, ammonia, acetic acid, methyl alcohol, turf-oil, and paraffin wax, formed during the distillation of turf, do not appear to vary much with the nature of the retort used, as the results of the experiments of Kane and Sullivan, given in the following table, indicate:—

	RETORT CLOSED AT ONE END.			RETORT OPEN AT BOTH ENDS.		
Percentage of	Light Turf.	Medium Turf.	Dense Turf.	Light Turf.	Medium Turf.	Dense Turf.
Ammonia, ..	0·187	0·393	0·181	0·322	0·334	0·194
Acetic Acid, ..	0·296	0·286	0·161	0·179	0·268	0·174
Methyl Alcohol, ..	0·171	0·197	0·119	0·158	0·156	0·106
Wax, ...	0·179	0·075	0·112	0·169	0·156	0·119
Oil, ...	1·148	1·136	0·913	1·220	0·946	1·012

According to more recent results of Thenius 100 lb. of dry turf-tar give on distillation :—

16 lb. crude light petroleum,
30 lb. crude heavy petroleum,
15 lb. crude lubricating oil,
12 lb. crude wax,
16 lb. crude asphalt,
11 lb. gas and loss.

On purification of the products Thenius obtained from 100 lb. of tar :—

12 lb. pure light petroleum,
25 lb. pure heavy petroleum,
15 lb. pure lubricating oil,
2 lb. pure wax,
10 lb. pure creosote,
16 lb. of asphalt,
23 lb. loss.

The same observer states that he obtained from good air-dried turf :—

1·76 per cent. light petroleum,
2·56 per cent. heavy petroleum,
1·77 per cent. lubricating oil,
0·30 per cent. wax,
1·56 per cent. asphalt,
35·34 per cent. charcoal,
40·00 per cent. gas-water,
1·08 per cent. creosote,
15·63 per cent. gas and loss.

From 100 lb. of the gas-water he obtained 2 lb. of methyl alcohol, 4 lb. of ammonium sulphate, and one-fifth of a lb. of pyridine bases.

According to Vohl 100 lb. of gas-water contains :—

1·58 lb. acetic acid,
0·764 lb. methyl alcohol,
0·086 lb. ammonia,
0·207 lb. butyric and valerianic acids.

The accounts published in a prospectus by the Irish Peat Company about fifty years ago showed that on a working capital of £11,717 they had a net gain of £11,908, made up as follows:—

EXPENDITURE.	£	s.	d.	INCOME.	£	s.	d.
365,000 tons of Turf, at 2*s.* per ton, ...	3650	0	0	365 tons of Ammonium Sulphate, at £12 per ton, ..	4380	0	0
455 tons of Sulphuric Acid, at £7 per ton, ...	3185	0	0	255 tons of Calcium Acetate, at £14 per ton, ...	3570	0	0
Depreciation Fund for Plant,	700	0	0	19,000 gallons of Methyl Alcohol, at 5*s.* per gallon,	4750	0	0
Wages, ...	2000	0	0	109,500 lb. of Paraffin Wax, at 1*s.* per lb., ...	5475	0	0
Cost of Transport, &c., ..	2182	0	0	73,000 gallons of Petroleum, at 1*s.* per gallon, ..	3650	0	0
				36,000 gallons of Lubricating Oil, at 1*s.*, ...	1800	0	0
				Gross Income, ..	£23,625	0	0
				Expenditure, ..	11,717	0	0
TOTAL, ..	£11,717	0	0	NET GAIN, ..	£11,908	0	0

The cost of the buildings and plant was £10,000, so that the net gain—£11,908—on the total capital involved—£21,717—corresponded to a dividend of 54 per cent.

The price paid for the air-dried turf, 2*s.* per ton, was only one-third of that which would have to be paid at the present day. It would, moreover, be impossible at the current prices to realize for the methyl alcohol, calcium acetate, wax, and oil, much more than one-half the sums given in the above profit and loss account.

Ziegler has estimated the net gain of a modern factory, fully equipped for the distillation of peat and the manufacture of peat-moss litter, as follows :—

Initial Expenses.	£
Peat Distillation Factory, ...	11,000
Purifying tar and gas-water, ...	1,200
Wax factory, ...	1,650
Turf machines and power-gas furnace,	4,000
Peat-litter factory, ...	750
Site, dwellings, &c., ...	1,400
	20,000
Working Capital, ..	10,000
Total, ..	30,000

Expenditure.	£
22,500 tons machine-turf, at 5*s.* per ton ..	5,625
Cost of manufacturing 3,000 tons peat-moss litter, ...	1,200
Wages, ...	2,500
Interest on Capital, ...	2,000
Cost of patents, ...	500
Working expenses and insurance ..	2,000
Other expenses, ...	380
Total, ..	14,205

Income.	£
5,000 tons turf-charcoal, at £2 per ton, ..	10,000
250 tons charcoal-igniters, at £5 per ton,	1,250
3,750 tons half-coked turf, at £1 per ton,	3,750
90 tons wax, at £20 per ton, ...	1,800
525 tons oil, at £5 10*s.* per ton, ...	2,887·5
75 tons ammonium sulphate, at £11 per ton,	825
105 tons calcium acetate, at £6 per ton, ..	630
37·5 tons methyl alcohol, at £35 per ton, ..	1,312·5
3,000 tons peat-moss litter, at 15*s.* per ton,	2,250
Gross income, ..	24,705
Expenditure, ..	14,205
Net gain, ..	10,500

So that under very favourable conditions it may be possible, at the present rates, if the above estimate of Ziegler be assumed to be correct, by combining the preparation of turf-tar and gas-water with that of peat-charcoal and peat-moss litter, to earn a dividend of 30 per cent. on the gross capital. The success of the factory will, however, vary not only with the local prices for the various products, but also with the amount of tar, gas-water, &c., obtainable from the peat. If 100 tons of turf give a smaller yield of tar than 4 tons, the working of the tar for the various products mentioned above can scarcely be made remunerative.

7. *Turf-Gas. Illuminating Gas from Turf.*

The distillation of turf from retorts gives a gas similar to that got from coal, which can be used for illuminating purposes. Since the illuminating power of turf-gas, like that of coal-gas, increases with the percentage of unsaturated or heavy hydrocarbons contained in it, the retort used for the preparation of turf-gas is constructed in such a manner that so much as possible of the tar will be converted into heavy hydrocarbons; and for the same reason the distillation is carried on at a high temperature.

At Uetersen, in Holstein, illuminating gas was prepared by heating turf in a retort and "cracking" the tar contained in the gas by leading it successively through three smaller iron tubes placed immediately above the retort. The tar, which had escaped decomposition, and the gas-water were collected in a condenser. In a period of 24 hours each retort was capable of affording 7,500 cubic feet of gas from 13 cwt. of turf.

Volume of the Gas.

Versmann found that when 1 cwt. of dry turf was distilled from an iron retort 519 cubic feet of gas were produced. According to Körner 1 cwt. of Bührmoos turf gave 510 cubic feet of gas, which, when burned at the rate of 5 cubic feet per hour, had an illuminating power equal to that of 22 standard candles, i.e. nearly twice that of coal-gas burning under the same conditions. Gräser and Schuppler found for the same weight of Bührmoos turf 445 and 475 cubic feet of turf-gas respectively, so that the average volume of turf-gas obtainable from 1 cwt. of Bührmoos turf is 475 cubic feet.

The volume of gas which can be got from 1 cwt. of good turf, although much less than that which can be prepared from the same weight of boghead coal, is, when the distillation has been carried out at a high temperature, and when suitable arrangements have been made for "cracking" the tar, very nearly equal to that which can be got from Newcastle coal, as the following table indicates:—

1 cwt. of	Cubic feet of gas.
Bührmoos Turf, ...	475
English Turf, ...	519
Cannel coal, ...	570
Boghead coal, ...	800
Wood, ...	605

Composition of Turf-Gas.

The composition of turf-gas varies within fairly wide limits, owing to the differences in the samples of turf distilled and in the methods of distillation employed. The following numbers may, however, be taken as typical:—

	Percentage.
Methane, ...	30
Carbon dioxide, ...	30
Hydrogen, ...	19
Carbon monoxide, ...	14
Heavy hydrocarbons, ...	7
Nitrogen, ...	Trace.
	100

The percentage of carbon dioxide in the gas increases as the percentage of water in the turf increases and as the density of the turf decreases. Again, the higher the temperature and the longer the tar is kept in contact with the hot retort, the greater the volume of the gas and the higher the percentage of heavy hydrocarbons contained in it.

Sulphuretted hydrogen is generally present in the crude gas got by the distillation of dense peat from lowland bogs.

Purification of Turf-Gas.

Turf-gas is purified in a manner similar to that in which coal-gas is purified. The tar and gas-water are removed by passing the gas through a condenser, and the carbon dioxide and sulphuretted hydrogen are absorbed from the coal-gas by lime contained in purifying towers. The chief obstacle to the success of the industry is the large amount of carbon dioxide contained in the crude turf-gas. The amount of lime necessary for the purification of the turf-gas is about twelve times that required for the same volume of crude coal-gas. The size of the purifying towers can be diminished, and at the same time a much more valuable coke can be obtained, by replacing the ordinary turf used in the distillation by dense machine-turf.

The illuminating power of purified turf-gas is greater than that of coal-gas; but the cost of its manufacture is for European countries too great to allow of the manufacture being carried on with commercial success.

The purified gas has the following composition:—

	Percentage.
Methane,	42·5
Hydrogen,	27·5
Carbon Monoxide,	20·0
Heavy Hydrocarbons,	9·5
Carbon Dioxide,	0·2
Nitrogen,	0·3
	100

Turf-gas was made and utilized many years ago on a small scale in County Westmeath, Ireland, and on a large scale in factories at Paris, Uetersen, Heide, and Salzburg; but owing to the large number of retorts necessary for the manufacture, and the abnormally high cost of freeing the gas from its impurities, its preparation was, after a few years' trial, abandoned.

For illuminating purposes it would probably be more economical to convert the turf into "power-gas," and utilize the latter for the generation of electricity in a suitable plant.

8. *Heating Gas from Turf.*

For heating purposes three kinds of gas can be prepared from turf—"generator-gas," "water-gas," and "Dowson-gas."

"*Generator-gas*" is prepared by burning turf in a quantity of air which is barely sufficient to convert all the carbon of the turf into carbon monoxide. According to the equation

$$C_2 + \left(\underset{\text{air}}{4N_2, O_2}\right) = 2CO + 4N_2,$$

"generator-gas," prepared under ideal conditions, contains 34 per cent. carbonic oxide, and 66 per cent. nitrogen.

"*Water-gas,*" on the other hand, is the gas obtained from the inter-action of steam and charcoal at a high temperature, and as the equation for its preparation, $C_2 + 2H_2O = 2CO + 2H_2$, indicates, pure "water-gas" is a mixture in equal volumes of carbonic oxide and hydrogen.

"*Dowson,*" or "*mixed power-gas,*" is, as the second name indicates, a mixture of "generator-gas" and "water-gas," consisting in the ideal state of carbonic oxide, hydrogen, and nitrogen.

When prepared from a substance such as turf, which contains hydrogen as well as carbon, the three gases contain, in addition to the constituents mentioned above, smaller quantities of other gases (hydrocarbons, carbon dioxide, &c.).

Turf Generator-Gas.

The details of the construction of the furnaces, technically named "generators," in which turf "generator-gas" is manufactured, depend on the physical properties of the turf to be utilized. Where good *dense* turf is available, or where machine-turf can be easily procured, the generator here described has been found serviceable.

A furnace (fig. 16) is filled with turf to the height indicated by the dotted line in the figure, through the cylinder *b* whose edges are fastened by four screws to the plate *a*. As the combustion proceeds, air is drawn into the generator through the spaces between the grates *g* and *h* by the suction due to the escape of the hot gases through the canal *f*. In order to utilize for the preparation of "generator-gas" all the oxygen of the air which passes through the furnace, the free spaces between the bars of the grates should be about one half the total area of the grates, and the height of the column of fuel should be adjusted to obtain the best possible results. The ashes which tend to choke the free spaces of the grate can be removed by pokers inserted through the holes *c* in the mouth-plate. By removal of the plug *m* the interior of the furnace can be observed, and the canal *f* cleaned when required.

Though differing in detail, most of the modern turf-gas-"generators" are similar in principle to that described above.

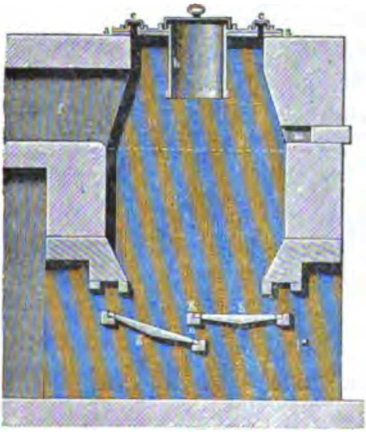

Fig. 16.—Gas-generator for dense turf.

At Falun, a turf-gas-"generator," whose principle was very similar to that used at a much earlier date at Kilberry, near Athy, has been employed. The generator was about 11 feet in height, circular in cross-section, with a basal diameter of 8 feet, and a somewhat smaller one at the orifice. It was filled with turf through an iron tube at its top to a height (ascertainable by means of a rod) of 5 or 6 feet above the surface of the hearth. The latter was pyramidal in shape, and could be cleaned through four openings situated beneath it. Slightly compressed air was forced into the generator through a tube under the grate, and the generator-gas escaped through a side-tube into condensers. Each condenser consisted of a number of brass tubes, open at both ends, and fitted water-tight into the perforations of two brass discs, which closed the top and bottom of the cylinder. A current of cold water circulated through the portions of the condensers not occupied by the brass tubes. The generator-gas was freed from tar and water by the condensers during its passage from the canal to the conduit pipe. The "gas-water" and tar were utilised in the manner already described. Mechanical precautions were taken against the danger of explosion, due either to accidental mixing of the generator-gas with the compressed air, or to the employment of peat containing too high a percentage of water.

Composition of Turf Generator-Gas.

Although ideal turf generator-gas consists of 34 per cent. of carbonic oxide and 66 per cent. of nitrogen, it is impossible in actual practice, with a fuel such as turf, to avoid the formation of carbon compounds other than carbonic oxide. Portion of the carbon of the turf is converted, even in the best furnaces, into carbon dioxide, a smaller quantity changing into volatile hydrocarbons.

According to Scherer good turf generator-gas has the following composition:—

	Percentage.
Carbonic Oxide, ...	22·4
Hydrogen, ...	0·5
Carbon Dioxide, ...	14·0
Nitrogen, ...	63·1

Mixed Power-Gas.

The principles of the two distinct methods which are in use for the preparation of "mixed power"-gas from turf differ in that the moist air is drawn into the generator by suction in the one case, and forced into it by pressure in the other.

Körting's Suction Power-Gas Generator.

The turf placed in the feeding funnel *D* (fig. 17) is discharged as required into the generator *A*, where it is burned in a limited supply of moist air drawn by the suction of the gas-engine through the space *P*, the grate *R*, and the opening *T*.

The hot volatile products pass down through the glowing coals to a canal at the base. The gas produced at first is allowed to escape through the pipe *E*, where it is tested from time to time. When the test indicates that the gas is of sufficient purity to be employed in the engine, the pipe *E* is closed and the gas is led through a scrubber *G*, a tube *L*, a water-pot *M*, and a purifier *S*, which contains saw-dust to free the gas from tarry matter. On emerging from the second water-pot *M*, the gas is sufficiently free from tar to be utilized directly in a gas-engine.

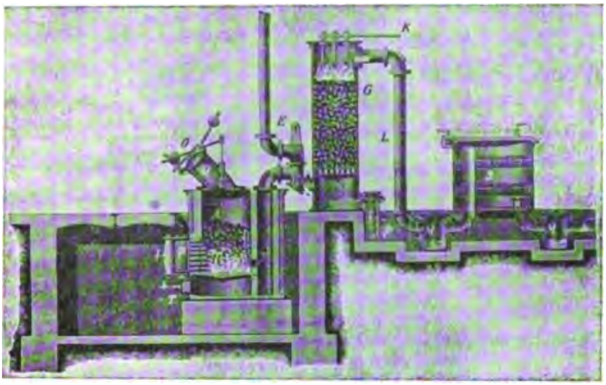

Fig. 17.—Körting's Suction Power-Gas Generator.

According to experiments made with this generator, 1 cwt. of turf, containing 26 per cent. of water, gave 100 cubic yards of power-gas, which had a calorific value of about 150 British thermal units per cubic foot of gas.

When turf whose calorific power is 2800 C.G.S. units is employed to produce the gas, a 100-h.-p. engine can be driven by its means with a consumption of 2½ lb. of turf per horse-power per hour.

Ziegler's Pressure Power-Gas Generator.

The furnace (fig. 18) is filled with turf through the funnel *H* and the movable valve *I*, the fire being ignited on the grates *cc* and *dd*, of which two are horizontal and two vertical. The moist air necessary for the combustion is forced through the openings *f*, and the "power-gas" passing up through the furnace, is directed inwards towards *a* by the contraction at the centre of the shaft. As the gas escapes from the top of the generator, and has not been long in contact with the hot coals, it is charged with too much tar to be capable of direct use in an engine. However, by means of condensers and scrubbers *p* it can be freed from the objectionable impurities, and then directly utilized.

A Ziegler "generator" is said to be capable of affording 180 cubic yards of power-gas, having a calorific power of 135 British thermal units per cubic foot of gas from 1 cwt. of average turf.

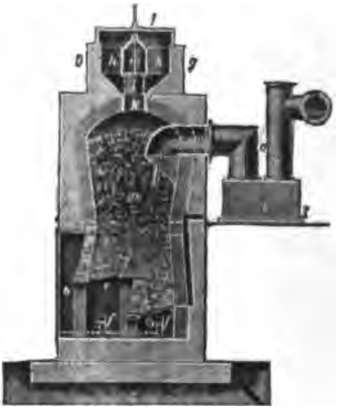

Fig. 18.—Ziegler's Pressure Power-Gas Generator.

Composition of Turf "Mixed Power-Gas."

The average composition of turf mixed power-gas is :—

	Percentage.
Carbonic Oxide,	30
Hydrogen,	10
Carbon Dioxide,	6
Hydrocarbons,	3
Nitrogen,	51
	100

The "mixed power-gas" contains a smaller percentage of nitrogen and a larger percentage of hydrogen than "generator-gas."

Owing to the high calorific power (34,462) of hydrogen, compared with that (2403) of carbon monoxide, that gas which is the richer in hydrogen will usually have the higher calorific power. It would seem, therefore, best to use wet turf for the preparation of power-gas; and no doubt this can be done when the "power-gas" exit tube is, as in Körting's generator, at the bottom of the furnace. If, however, as in Ziegler's generator, the gas exit tube is placed at the top of the furnace, the steam from the upper layers of turf will be carried undecomposed out of the furnace with the escaping gas, and the latter must be freed from the excessive moisture before it can be used in an engine.

The formation of the "water-gas" absorbs a portion of the heat possessed by the furnace, and renders it more available for industrial operations. Theoretically, the reactions which occur in its formation and utilization may be explained in the following manner:—

Steam abstracts a quantity of heat Q from the red-hot coals, and breaks up into hydrogen and oxygen.

$$2H_2O = 2H_2 + O_2 - Q.$$

The oxygen produced from the steam combines with the charcoal with the evolution of a quantity of heat Q' and formation of carbonic oxide

$$C_2 + O_2 = 2CO + Q'.$$

When the water-gas burns, its carbonic oxide combines with oxygen, evolving a quantity of heat Q''.

$$2CO + O_2 = 2CO_2 + Q'',$$

and its hydrogen combines with oxygen to form water evolving a quantity of heat Q,

$$2H_2 + O_2 = 2H_2O + Q.$$

The total quantity of heat abstracted from the furnace in the formation of the gas is $Q - Q'$, and the total quantity of heat set free in the combustion of the water-gas is $Q + Q''$, so that the net gain of heat $(Q' + Q'')$ due to the chemical changes which occur, is the same as that which would be got if the carbon were burned in oxygen only.

$$C_2 + O_2 = 2CO + Q'.$$
$$2CO + O_2 = 2CO_2 + Q'',$$

the two equations adding to

$$C_2 + 2O_2 = 2CO_2 + Q' + Q''.$$

On the other hand, it must not be forgotten that the large quantity of heat Q absorbed during the first stage of the reactions, and evolved during the combustion of the hydrogen of the water-gas, can be utilized much more economically for the production of power in the second form (water-gas) than in the first form (charcoal).

In small steam-engines only about 5 per cent., in the larger engines rarely more than 12 per cent., of the energy theoretically derivable from the fuel can be actually transformed into power. Gas-engines can utilize a much higher percentage (25) of the energy of the fuel, and possess also the important advantage that the percentage of the energy of the fuel convertible into power is almost independent of the size of the engine. Hence in recent years the steam-engines used in the smaller factories have in many cases been replaced by the more economical gas-engines.

Now that the difficulty experienced by the earlier workers with regard to the removal of the tar from the turf power-gas has been overcome, there seems a likelihood that in countries such as Ireland, whose industries, broadly speaking, are conducted on a small scale, turf power-gas will be in the future more widely utilized. Its widespread employment in industries (glass, porcelain, lime, &c.) which require a continuous fire of a high temperature, is certain to come sooner or later. In factories of the latter class turf power-gas has completely displaced the older forms of turf-fuel (anhydrous turf, turf-charcoal, and machine-turf). Its growing importance as a fuel is no doubt largely due to the ever-increasing popularity of the Siemens Regenerating Gas Furnace, in which the heat produced by the combustion of the gas is either absorbed at the hearth or brought back to it by the incoming gas and air to which that heat is imparted.

The manufacture of glass, for which Ireland was at one time well known in Europe, is one of the industries to which turf generator-gas is best adapted. A high and continuous temperature is required for the manufacture of the glass, and the absence of injurious substances like sulphur from the flame is essential for the preparation of glass of the finest quality.

The Neufriedrichsthaler Glass Factory at Uosz, which formerly spent £41 per week for the fuel-wood necessary to heat eight melting-pots capable of holding in all three and a half tons of glass, replaced the wood by turf generator-gas, and found that the same operations could be performed by means of the latter at a cost of only £26 per week for fuel. All the operations required in the manufacture of table-glass are performed at the Ignaz Glass Factory near Salzburg by means of the gas generated from seven tons of turf per ton of glass manufactured.

Among other glass factories which use turf-fuel, may be mentioned those of Suchenthal, Georgenthal, Schrems, Nagelberg, and Kolbermoor; the Nagelberg factory using upwards of 17,000 tons of turf yearly.

The initial cost of a turf-gas melting furnace is greater than that of the ordinary furnace employed for the same purpose; but the difference in cost is very quickly recovered by the decrease in expenditure for fuel. Two gas-generators are sufficient for a glass furnace with a melting-pot content of from four to six tons.

At Kolbermoor, Bührmoos, and Danzig excellent results were obtained in the porcelain, brick, tile, and lime industries; and according to a British Foreign Office report 280,000 tons of turf are used annually in the brick-kilns of Holland.

About thirty or forty years ago turf was extensively used in the iron and steel industries; but partly owing to the utilization of the gases from the blast furnaces associated with these industries, and partly owing to the fact that the iron ores which occur in peat districts are poor, its use in these industries has been gradually abandoned.

9. *Distillation of Turf at low Temperatures.—Preparation of Ammonium Sulphate from Turf.*

The action of heat on turf has been studied very carefully by Börnstein (Journ. f. Gasbeleuchtung, xlix., p. 627).

A sample of turf, whose percentage composition was Carbon 43·76, Hydrogen 4·16, Nitrogen 2·3, Oxygen 24·57, Sulphur 0·24, Water 17·03, and Ash 7·94, on distillation from a retort closed at one end, gave at 100°C. water, at 250° C. gas, at 325° C. tar, and at 400°C. a combustible gas. The turf-tar water was neutral below 350° C., and more or less alkaline above that temperature. The fraction which came over between 250° C. and 300° C. contained neither ammonia nor acetic acid; but the latter substances were contained in the fractions which distilled either below 250° C. or above 300° C. Pyrocatechin was present in the fractions collected above 350° C.

The ammonia formed during the distillation of the turf can be readily converted into ammonium sulphate—a valuable fertiliser. Since the difficulty of maintaining Nature's store of nitrogenous fertilisers has become generally recognized, and the possibility of supplementing that store by either the fixation of atmospheric nitrogen or the utilization of the nitrogen of fuel has attracted the attention of chemists, processes such as the "calcium nitrate," the "calcium cyanamide" and the "nitrobacterine," for the fixation of atmospheric nitrogen, have met with some success from a commercial standpoint. Similarly, attempts, which will now be described, have been made to improve the processes for converting the nitrogen of fuel into ammonium sulphate.

Remembering that at high temperatures ammonia decomposes into nitrogen and hydrogen, it will be obvious that if we wish to obtain the maximum yield of ammonia by the distillation of nitrogenous organic matter, we must carry out the distillation at a low temperature and remove the products from the retort as rapidly as possible. These conditions are most easily realized by distillation in a current of steam. Thus Mond (Jour. Soc. Chem. Ind., Presidential Address, 1889) found that by distilling coal in a current of steam, the yield of ammonia is almost twice as great as that got from the same sample of coal when the distillation is carried out in a current of air and steam. The process, however, was not economical, and the complicated apparatus required was too costly. More successful results were obtained by burning the coal in a current of moist air at the lowest possible temperature in a producer furnace. In the latter case 125 tons of coal gave about 4 tons of ammonium sulphate in addition to the producer gas.

In recent years several processes have been patented for increasing the yield of ammonia formed in the distillation of turf. In Hoering and Mjoen's furnace (D.R.P. 158032) provision is made by which the water evaporated from the turf acts on the hot fuel, increasing the yield of ammonia and tar. Ireland and Sugden have patented a method (D.R.P. 175401) for the preparation of ammonia from the nitrogen of the air by leading air and water-vapour through turf heated to a temperature of from 300° C. to 500° C. in upright iron retorts surrounded by fire-bricks. In the Woltereck process for the production of ammonia by the moist oxidation of peat, a mixture of air and water-vapour is passed over peat kept at a relatively low temperature in a specially constructed furnace.

During the past four years, experiments have been made at Carnlough, County Antrim, with a view to determine the commercial value of the method. In a pamphlet, for which I am indebted to the Secretary of the Chemicals Proprietary Company, Limited, recently published by that Company, the process is described as follows:—

"After the peat has undergone the necessary harvesting, it is conveyed to the works and automatically fed into hoppers worked with compressed air, and quickly dropped into the furnaces. Here it is subjected to moist combustion by means of a blast of air charged with water vapour at a regulated temperature. The resulting gases contain paraffin tars, acetic acid, and ammonia. The paraffin tars are removed by the "Woltereck" scrubber, which retains all tarry matter without causing any condensation and consequent loss of ammonia. The acetic acid is next absorbed in the alkali tower, where the gases meet a hot solution of soda or milk of lime and combine with it to form acetate of soda or of lime, which may afterwards be treated for the recovery of acetic acid or the production of acetone. The gases pass from the alkali tower to the acid towers, where they meet a stream of hot sulphuric acid, which combines with the ammonia to form sulphate of ammonia, the chief object of the process. After the acid is completely neutralized it is drawn off to the crystallizing vats. The solution of the sulphate is there further concentrated and allowed to crystallize, and after centrifuging, to remove any adhering liquor, is ready for shipment. The paraffin-tar is drawn off from the scrubber, when a sample of the oil therein solidifies on cooling. It is then subjected to distillation to remove the lighter oils, and a crude paraffin-wax worth £4 per ton remains without further purification. The acetate solution obtained from the alkali tower is evaporated to dryness, and distilled with sulphuric or hydrochloric acid to obtain acetic acid, or can be subjected to dry distillation to produce acetone."

Since the percentage (0·5 to 3) of nitrogen in dry turf varies greatly with the nature of the turf, it is important that in selecting a site for such a factory as that just mentioned due attention should be paid to the fact that turf from a "mountain" bog is relatively poorer in nitrogen than that from a "flat" bog. If the total nitrogen in 100 tons of anhydrous turf were converted into ammonium sulphate, the number of tons of the latter substance produced would vary from about 2 to 13 tons. In Mond's experiments on the distillation of coal in an atmosphere of air and steam it was found that about half the total nitrogen of the coal was contained in the ammonium sulphate recovered.

By the Woltereck process it is said that 100 tons of dry peat can give a minimum yield of 5 tons of ammonium sulphate. It is estimated that the cost of production of the sulphate of ammonia will be, after making all necessary allowances, £5 8*s.* 3*d.* per ton—the average selling price of the substance being about £12 per ton. In the course of the experiments at Carnlough it was also found that peat, containing up to 75 per cent. of water, could be employed with success in the process. If this be so, then the manufacture can be carried on during all the seasons of the year, and made almost independent of climatic conditions.

The installation of plant, designed for the production of a minimum output of 5,000 tons of ammonium sulphate per annum, together with the necessary offices and dwellings, is now being completed at Carnlough. It is estimated that the total cost will be about £80,000.

Two appendices are attached—one giving the imports of peat-moss litter into Ireland within the last few years and the exports from Ireland of peat-moss litter during the same period; the other being a bibliography of the subjects treated above. The bibliography is incomplete, but may, nevertheless, be of some use to those who wish to pursue further any of the points discussed in these brief reports.

APPENDIX A.

Statistics collected by the Department of Agriculture of the Imports and Exports of Peat-Moss Litter and Peat-Fuel (Ireland).

IMPORTS OF PEAT-LITTER.

INTO	FROM	QUANTITIES.			VALUE.		
		1904.	1905.	1906.	1904.	1905.	1906.
		Cwt.	Cwt.	Cwt.	£	£	£
Belfast,	Holland, .	58,580	42,740	36,820	3,677	2,690	2,291
Cork,	Holland, .	8,220	5,860	1,240	699	488	102
Dublin,	Holland, .	11,860	16,680	5,700	1,052	1,297	478
	Gt. Britain,	329	873	—	29	69	—
	TOTAL,	12,189	17,553	5,700	1,081	1,366	478
Other Ports,	Gt. Britain,	314	1,763	3,364	15	112	224
Ireland,	Holland, .	78,660	65,280	43,760	5,428	4,475	2,871
	Gt. Britain,	643	2,636	3,364	44	181	224
	TOTAL,	79,303	67,916	47,124	5,472	4,656	3,095

EXPORTS OF PEAT-FUEL AND PEAT-LITTER.[1]

	Quantity.			Value.		
	1904.	1905.	1906.	1904.	1905.	1906.
	Cwt.	Cwt.	Cwt.	£	£	£
Belfast, ...	3,872	10,642	47,560	290	665	2,973
Cork, ...	—	—	—	—	—	—
Dublin, ...	984	119	6,257	74	8	391
Other Ports, ..	12	64	1,444	1	4	90
TOTAL, ..	4,868	10,825	55,261	365	677	3,454

APPENDIX B.

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[1] We cannot distinguish between Peat-fuel and Peat-litter exported. All was exported to Great Britain.

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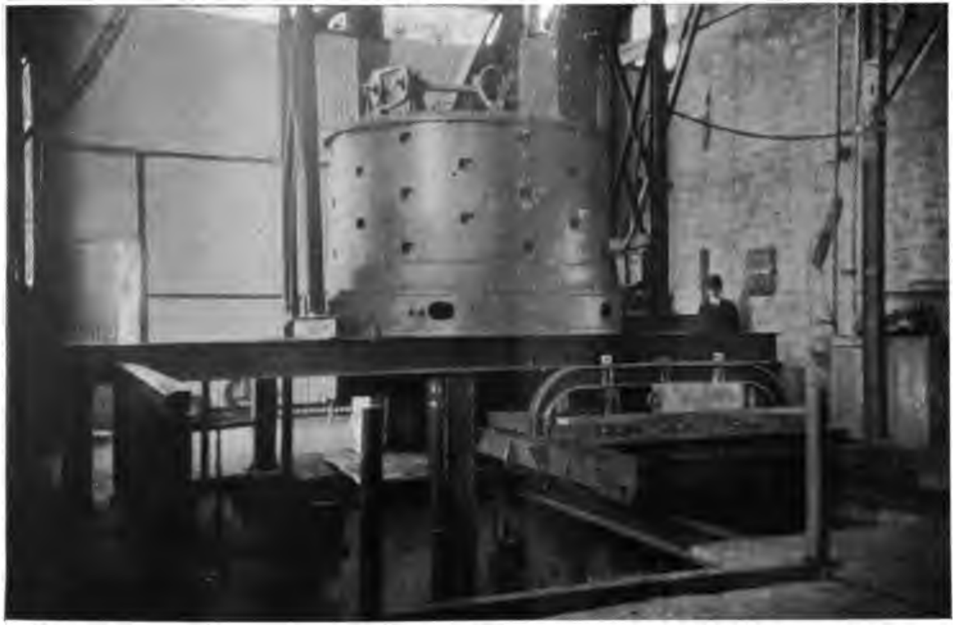
EXPLANATION OF PLATE XLVI.

PLATE XLVI.

Peat Electrolyser and Hydro-extractor, Kilberry.



EXPLANATION OF PLATE XLVII.

PLATE XLVII.

Fig.

1. Peat Grab-Machine, Kilberry.

2. Electro-Peat Factory, Kilberry (Drying Shed in centre).

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again—so much so, that by the end of November more than two-thirds of the whole crop of this variety was badly diseased. Other varieties, grown under the same conditions and stored in a similar manner, had hitherto remained unattacked; but during this winter a few tubers of another variety ("Satisfaction") also showed the disease.

It was evident, therefore, that the disease was making great headway from year to year, and was seriously threatening the continued cultivation of the variety "Snowdrop" on this farm.

II.—EXAMINATION OF THE DISEASED TUBERS.

The tubers presented at the first glance all the signs of "dry rot" (see Pl. XLVIII., fig. 1). They were fairly firm to the touch, but more or less shrivelled, with the skin contracted into wavy wrinkles. At various points on the tubers the skins were broken through by fungus pustules. These were whitish on the surface; but on gently rubbing them the base of the pustule was seen to be of a blue colour. On standing for some time, especially in the light, the surface of the pustules changed from white to a salmon-pink; on the less well-illuminated undersides of the tubers and on those in the dark, the pustules remained for a long time whitish-blue. On cutting open the tubers, a sharp contrast was seen between the still healthy tissues of the tuber and the dark brown diseased portions. In tubers on which the disease had a greater hold cavities were frequently found within the brown diseased parts, these being often lined with white fungus mycelium. There was no offensive smell from the tubers. The juice expressed from the diseased tissues gave a distinctly alkaline reaction with litmus; whereas the juice from the healthy tissue was slightly acid in character.

Examination under the microscope of sections through the pustules showed that each consisted at its base of a stroma of closely interwoven hyphæ, and at its free end of a fringe of branched conidiophores, producing characteristically sickle-shaped one-, two-, or three-septate conidia. The stroma was blue in colour, but, on the addition of a drop of dilute acid, this colour was quickly changed to red.

The fungus, which was identified as *Fusarium Solani*, Sacc., was present on all the diseased tubers examined, and not only so, but there was no sign of any other fungus on the tubers in question which could be held responsible for the state they were in.

A very striking thing was the large number of diseased tubers which also showed obvious wounds, probably made by a spade or the prong of a fork (see Pl. XLVIII., fig. 2). Eighty per cent. of the diseased tubers examined showed such large and obvious wounds, and it was clear enough in every case that the disease was associated with the wound, being seen to spread from the wounded portion to the unwounded both by the situation of the fungus pustules and by the progress of the internal brown rot as seen on slicing the tuber open. In the other 20 per cent. of cases the disease had already obtained such a hold on the tubers that they were very much shrivelled and shrunk. No obvious wounds were seen in them; but, owing to shrinkage and wrinkling, smaller wounds, which might quite possibly have been present at the start, would, at this stage, have been quite unrecognizable.

A second case of the same rot from another source came under notice shortly after the first one. Here as much as 86 per cent. of the diseased tubers showed obvious wounds. In the other 14 per cent. there were no obvious wounds, but the disease had entered at, and was spreading from, the "heel" end of the tuber.

III. Is *Fusarium Solani*, SACC., THE CAUSE OF THE DRY ROT?

The appearance of the tubers just described would seem to point to the above-mentioned fungus as being the direct cause of the rot. On looking into the literature of the subject, however, there seemed to be some doubt as to whether this fungus is a true parasite, or whether it only lives saprophytically on the tubers after they have been killed by some other means.

The present case offered a good chance of going into this matter, for whereas in many cases of rotting of the potato tuber the causes are complex and not easy to disentangle from one another, in the present case it was difficult to account for the observed facts unless the fungus in question were a true parasite. Before describing the experiments carried out to settle the question, however, a brief review of the principal literature on the subject will be desirable.

Fusarium Solani, Sacc., is a fungus which has been known for a long time as frequently *associated with* the rotting of tubers during storage; but its parasitic nature has not always been admitted. In a paper by Reinke and Berthold,[1] published in 1879, the authors state that it had been proved by de Bary that this fungus (along with others) is *not* a parasite, but only lives on the potato tuber after it has been previously killed by *Phytophthora*. They further add that their own experiments entirely confirm this view, namely, that *F. Solani* is a saprophyte for which *Phytophthora* prepares the way. For a long time subsequently it was considered that the rotting of potato tubers was due either to *Phytophthora* alone, or that after the tuber had been killed by this parasite various saprophytic bacteria or moulds might complete the process. Sorauer[2] states that this is not always the case, and points out that rotting may be caused by bacteria without a preliminary attack of *Phytophthora*. With regard to *Fusarium*, Sorauer says that although de Bary, and also Reinke and Berthold, failed to infect sound tubers with this fungus, yet he believes that it is to be looked upon as one of the causes disposing the tuber to rot. He says the fact cannot be overlooked that the conidia of *Fusarium* germinate easily on the cut surface of sound tubers, and the mycelium quickly enters the superficial layers and kills them. He is of opinion that this fungus paves the way for bacteria, in that it favours the destruction of the substance of the tuber by them, and that it is itself at the same time furthered in its own growth by the decomposition products arising from them. He looks upon the fungus as, under ordinary circumstances, probably only a saprophyte, which, however, under special circumstances, can become a parasite.

Frank,[3] however, ten years later, still adheres to the opinion that *Fusarium* is only a saprophyte, and causes the destruction of the tuber only after it has been previously killed by *Phytophthora*.

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[1] Reinke u. Berthold. Die Zersetzung der Kartoffel durch Pilze. Berlin, 1879.

[2] Sorauer, Pflanzenkrankheiten. 2. Aufl. Berlin, 1886.

[3] Frank, Die Krankheiten der Pflanzen. 2. Aufl. Bd. 2. Breslau, 1896.

In this year (1896) the first account of definite inoculation experiments with *Fusarium* was given by Pizzigoni,[1] who, by means of pure cultures, showed that the dry rot of the potato was directly due to *Fusarium Solani*.

In the same year Wehmer[2] published a preliminary account of the disease and of infection experiments, by means of which he and Borchers were able to show that this fungus is a parasite, and that it is the immediate cause of dry rot. Success in getting infection to take place depends, according to Wehmer, largely on the temperature and moisture conditions at the time; and if these conditions are rightly chosen, inoculation can be made to succeed with ease. In the following year (1897) Wehmer[3] published a much longer and fuller account of his experiments, which seem to leave no room for doubt as to the parasitic nature of this fungus. On the other hand, Roze[4] comes to the conclusion that dry rot is caused by a *Micrococcus albidus*, which prepares the way for the saprophytic *Fusarium Solani*.

Frank, in his "Kampfbuch," published in this year, says:—"Auf schon ganz faulen Kartoffeln tritt erst während der Aufbewahrung im Herbst und Winter ein Schimmelpilz als sekundarer Begleiter der Fäule auf. . . ." A little further on, however, he mentions Wehmer's results, and says that further search must be made as to whether this fungus can appear in the field before the lifting of the crop, which he thinks to be not unlikely, a point which Wehmer[5] had already mentioned the previous year.

In the following year Frank,[6] in a paper summarizing the various causes of rotting in potato tubers, says that he is able to confirm Wehmer's results, and consequently now looks upon this *Fusarium* as a true parasite.

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[1] Pizzigoni, A., "Concrena secca ed umida delle Patate." Nuova giorn. bot. italiano, N. S., vol. iii., 1896, p. 50. Ref. in Just's bot. Jahresbericht, Abth. i., Bd. 24, 1899, p. 392, and in Hedwigia, Bd. 35, 1896, p. 24.

[2] Wehmer, C., Ber. d. Deutsch bot. Ges., Bd. 14, 1896, p. 101.

[3] Wehmer, C., Centralb. f. Bakteriologie, Abth. ii., Bd. 3, 1897, p. 727.

[4] Bull. Soc. Myc. France, xiii., 1897, p. 23.

[5] Centralb. für Bakteriologie, Abth. ii., Bd. 2, 1896, p. 787.

[6] Frank, Untersuchungen über die verschiedenen Erreger der Kartoffelfäule. Ber. d. Deutsch bot. Ges., Bd. 16, 1898, p. 273.

In spite of this accumulating evidence as to the truly parasitic nature of *Fusarium Solani*, Massee,[1] in 1903, merely says of it that it is "said to cause the rotting of potato tubers, but the matter requires further investigation." In a lecture to the Royal Horticultural Society in 1904, however, he is reported[2] as stating that this fungus is one of the commonest of diseases attacking stored potatoes, thus apparently fully assuming its parasitic nature. He describes it as one of the stages in the life-history of *Nectria Solani* (Pers.), *Cephalosporium* and *Monosporium* being other stages in the same life-history.

Turning now to the latest important text-book on plant-diseases, it will be found that Lindau,[3] in a section dealing with *Phytophthora* rot in potato tubers, mentions the older work of Reinke and Berthold, repeating that *Fusarium* (along with one or two other moulds) is only a harmless parasite, and only able to accelerate the rotting of the tubers under certain conditions, namely, when they have been previously killed by *Phytophthora*.[4]

From this brief survey of the literature on the subject,[5] it will be seen that evidence as to the parasitic nature of *Fusarium Solani* has been gradually accumulating, but that in the minds of some at least there still seems some doubt on the matter. Since no account could be found dealing in detail with inoculation experiments, such as would serve to confirm those of Pizzigoni and Wehmer, or otherwise, it was decided to carry out the experiments which will now be described, with this object in view.

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[1] Massee, G., Text Book of Plant Diseases. London, 1903, p. 333.

[2] Gardener's Chronicle, No. 904. April, 1904, p. 257.

[3] Sorauer, P., Handbuch der Pflanzenkrankheiten. 3. Auf., in Gemeinschaft mit G. Lindau und L. Reh. Berlin, 1905, Lief. 3, p. 134.

[4] Since the above was written, this book, which was being issued in parts, has been completed, and in dealing with *F. Solani* on p. 469, Pizzigoni's and Wehmer's experiments are alluded to.

[5] Since this was written, and after the experiments described in this paper had been carried out, an important paper on the dry rot of potatoes by E. F. Smith and D. B. Swingle, published as Bull. 55, Bureau of Plant Industry, United States Department of Agriculture, 1904, came under notice. The parasitic nature of the fungus *Fusarium oxysporum*, Schlecht (= *F. Solani*, Sacc.), is here assumed, and the paper deals with the attack on the potato plant as a whole. It is shown that the tubers may contract the disease primarily from the soil, and that tubers with the disease in them may be unwittingly planted as sets, and thus give rise to diseased plants with a new set of affected tubers.

IV.—INOCULATION EXPERIMENTS WITH *Fusarium Solani*, Sacc.

The following experiments were carried out in the Biological Department of the Albert Agricultural College, Glasnevin :—

(1) *Infection of healthy tubers by contact with diseased ones.*—On December 2nd, 1904, four large glass jars, with a capacity of five litres each, were taken, and at the bottom of each a layer of largish clean pebbles was placed. The object of the pebbles was to prevent the tubers from lying in water at the bottom of the jars. A small quantity of water was poured into two of these jars; the other two were kept dry. On the pebbles in one of the dry jars and in one of the wet jars were placed several carefully selected, washed, sound tubers of the variety "Black Skerries." Over these was placed a layer of badly diseased tubers (variety "Ninetyfold"), with numerous conidia-bearing pustules of *F. Solani* on them, and above these again another layer of selected, sound "Black Skerries." Thus there was a layer of diseased tubers separating two layers of healthy, sound, and unwounded ones. The two other jars (one dry and one wet) were filled in the same manner, except that instead of the healthy "Black Skerries" being put in whole, they were first cut into halves or wounded, the wounded surfaces coming in some cases into actual contact with the pustules of the diseased tubers. In all four cases a layer of cotton wool was placed on the top of the jars to keep out dust; they were wrapped round with brown paper to exclude light, and were kept in an unheated lobby, and their contents left undisturbed until March 29th, 1905.

On January 27th, 1905, an experiment similar to the above was started, the only differences being that perfectly sound tubers of the "Snowdrop" variety were used instead of the "Black Skerries," and diseased tubers of "Snowdrop" variety were used as inoculating material. The contents of these jars were also investigated on March 29th, 1905.

These two experiments were intended to ascertain if infection would take place by contact in the dark at a fairly low temperature (*a*) in sound tubers, (*b*) in wounded tubers, (*c*) under fairly dry conditions, (*d*) under wet conditions.

The results may be conveniently summarized in the following table:—

EXPERIMENT I.	WET		DRY	
	WHOLE	CUT	WHOLE	CUT
Healthy "Black Skerries" in contact with diseased "Ninetyfold" for nearly four months.	All the tubers (14) remained sound, except one, which showed *slight* signs of *wet* rot.	Five of the eight upper portions and one of the three lower portions typically dry rotted.	All the tubers remained sound.	All of the portions remained sound.
EXPERIMENT II. Healthy "Snowdrops" in contact with diseased "Snowdrops" for nearly three months.	All the tubers (7) remained sound.	All the portions (5) in the upper layer and one of three in the lower typically dry rotted.	One tuber in the lower layer typically dry rotted, all the others (6) still sound.	All of the portions (8) became typically dry rotted.

From these results it seems that infection of "Black Skerries" by *Fusarium* from "Ninetyfold" only takes place by contact provided the conditions are kept moist, and so long as the tubers are cut or wounded, and not intact. It is also clear that cut "Snowdrops" may become infected by contact with the diseased "Snowdrops," whether the conditions are moist or dry, but in only one case was a sound tuber affected, and then under dry conditions. There is thus a possibility of sound unwounded tubers becoming infected, but apparently only with difficulty. The experiments also suggest that infection may be easier when the fungus is already growing on the same variety, and that one variety may be more resistant to the disease than another. The chief differences between these results and those of similar experiments of Wehmer's[1] are that he succeeded in infecting a larger proportion of unwounded tubers than was the case here, and that in the present case a larger proportion of cut or wounded tubers became infected than with Wehmer.

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[1] Centralblatt für Bakt., Abth. ii., Bd. 1., 1897, p. 727.

(2) *Infection of healthy tubers by means of conidia from the pustules of diseased ones.*—In these inoculations small slits were made in the skins of healthy "Black Skerries" tubers on December 1st, 1904, and into these conidia from the pustules from "Ninetyfold" varieties were introduced, the flap of skin being pressed close again. The tubers were kept for the first few days in a glass basin with glass lid, but were not moistened; later on, the lid was removed occasionally so that no moisture condensed on them.

The fungus attack proceeded rather slowly, but on March 27th, 1905, there was only one tuber out of eleven inoculated which did not show the disease. Of the remaining ten, seven became diseased in a perfectly typical manner, the other three being devoid of external pustules, but showing the characteristic of internally advancing brown dry rot.

(3) *Infection of healthy tubers with pieces of diseased tissue cut from the interior of diseased tubers.*—In these inoculations slits were made as in (2) in healthy "Black Skerries" tubers, and bits of diseased tissue, free from conidia, from diseased "Ninetyfold" tubers were introduced, the slits being closed by pressure with the finger. In six cases out of eight the disease attacked the tubers in a perfectly typical manner; in the other two cases the slit made was too small, and the small pieces of inoculating tissue completely dried up without causing infection. The tubers here were kept in the same way as in (2).

(4) *Infection of healthy tubers from pure cultures of the fungus.*—The foregoing experiments clearly demonstrate that in practice healthy tubers may contract the disease by contact with diseased ones, but they do not prove absolutely the parasitic nature of the fungus. To prove this it was necessary to resort to the inoculation of sterilized tubers with pure cultures of the fungus. For this purpose conidia were shaken up in sterile water, and drops of this plated out in, and also streaked on the surface of potato-gelatine and glucose-gelatine. Bacterial colonies were exceedingly few, and good isolated individuals of *Fusarium* were easily obtained, which, however, only grew vegetatively and did not produce any conidia. That the individuals were those of

Fusarium was determined by observation under the microscope of the germinated conidia from which the mycelium developed.

On February 1st, 1905, three perfectly sound "Snowdrop" tubers were well washed, dried, and then treated for fifteen minutes with corrosive sublimate solution. After thoroughly washing away the corrosive sublimate with sterile water two of the tubers were slightly wounded at one end with a sterile needle, and inoculated with a pure culture of *Fusarium* mycelium. On the unwounded surface of the third tuber mycelium, together with some of the adhering gelatine, was placed, and the three tubers were kept covered with a previously disinfected glass bell jar on a sterile plate in a dark cupboard at ordinary room-temperature. The last-named tuber remained perfectly sound, and sprouted normally later on. The other two tubers developed the disease in a perfectly typical manner, and eventually became totally shrivelled up to a dry hard mass.

The certainty and ease with which these wound-inoculations with pure cultures succeeded made it unnecessary to carry the matter further, and it is quite clear that *Fusarium Solani* is a true parasite capable of directly producing the disease known as "dry rot" in absolutely healthy potato tubers.

V.—Preventive Measures.

In all probability the primary attack in some of the tubers which perish from dry rot during subsequent storage occurs in the soil. But it seems pretty certain that the disease is largely spread from tuber to tuber during storage, especially if diseased and healthy tubers are in contact with one another, and even if this is not the case. The following experiments carried out at the farm in Kilkenny, during the month of January, illustrate the risks run by storing healthy tubers, especially if wounded, in the same loft as diseased ones, owing to the way in which the spores of the fungus become distributed.

(1) A well-cleaned, healthy "Black Skerries" tuber was cut in two, and the cut surfaces smeared against the whitewashed wall of the loft. After keeping the two halves fairly moist for a few weeks, typical dry rot set in, and pustules, with *Fusarium* conidia, developed.

(2) Four half-tubers, similar to those in (1), were laid on the floor of the loft, with the cut surfaces upwards, for seventy hours. One of these halves developed *Fusarium* pustules. It may be mentioned that care was taken not to stir up dust in the loft during this experiment; but even so floating spores are seen to have been present.

(3) Eight half-tubers, similar to those in 1 and 2, were smeared with their cut-surfaces against the floor of the loft. After keeping the portions in a fairly moist condition for a few weeks, all of them became diseased with *Fusarium* in the most typical manner.

(4) Some healthy and perfectly sound whole "Black Skerries" tubers were placed on the floor of the loft, covered over with diseased tubers, and left in this position for four days. After keeping these tubers in a fairly moist condition for a period of five months, they remained perfectly healthy, and produced sprouts normally. This result is in agreement with that of Expt. I, p. 554. It will thus be seen that living germs of this disease were present on the floor and the walls as well as in the air of the loft in which the tubers were stored, having been spread there from the affected tubers.

The following measures for preventing the spread of the disease during storage may be suggested:—

(*a*) Reject any suspicious-looking tubers observed during lifting, and do not store them.

(*b*) Keep a careful look-out for the appearance of the disease, and remove any affected tubers as soon as observed. Repeat this inspection at frequent intervals.

(*c*) Take as much care as possible during the lifting and subsequent handling of the crop, to avoid wounding the tubers.

(*d*) Use up wounded tubers as soon as possible, and do not store them for use as sets.

For what length of time the spores retain their vitality is not known. It is perhaps scarcely likely that they would remain in a living condition from one season to the next; nevertheless it was thought not superfluous to thoroughly disinfect the barn. This was carried out in August, 1905, the floor, shelves, and walls being thoroughly moistened with a two per cent. solution of copper sulphate, so that the incoming crop of tubers could not possibly become infected by living spores which were lurking in the barn from diseased tubers of the previous crop.

Amongst the tubers stored in the barn during the subsequent winter, the percentage of dry-rotted tubers, as compared with previous seasons, was considerably lessened, and whereas in former seasons the rot commenced in about three weeks after the crop had been stored, in this year the rot did not begin to make its appearance until two months later. Seeing that the barn was disinfected, the fungus must have been brought in along with the tubers, and the primary source of infection seems therefore to lie in the soil. During subsequent seasons, however, the susceptibility of the "Snowdrop" variety to dry-rot has been so great that its cultivation on this particular farm has been abandoned.

In order to obviate the disease, it would be necessary to plant only sets which are perfectly healthy, and to avoid planting them in a soil which contains the fungus. This of course is a "counsel of perfection," and in practice would be difficult to carry out. In view, however, of the considerable number of potato diseases, both bacterial and fungoid, which are now known to be definitely carried over from season to season by the "sets" planted, the question arises as to whether some practical means could not be evolved by which "seed" potatoes could be sampled and tested for the presence of disease in somewhat the same way as ordinary seeds are tested for purity and germination.

At the present time judgment is passed in a somewhat superficial manner, and almost entirely on the external appearance of the tubers; whereas it is well known that what appears externally to be a perfectly healthy tuber may yet have the germs of disease within it.

At first sight considerable difficulties present themselves in the way of carrying out this suggestion; but it is by no means certain that they could not be overcome.

It is, however, certain that if the planting of only perfectly healthy tubers could be carried out, the losses in the potato crop would be very considerably diminished.

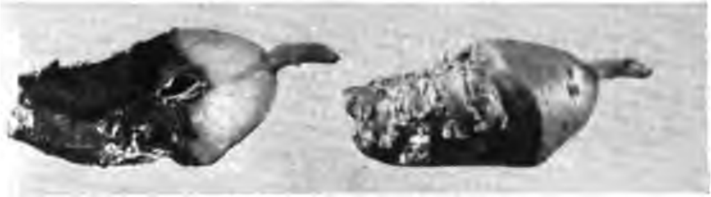
EXPLANATION OF PLATE XLVIII.

PLATE XLVIII.

FIG.

1.—The two halves of a sliced tuber badly attacked by dry rot. On the left the interior cut surface is seen with the rot gradually advancing from the "heel" end towards the still healthy "rose" end, which bears a sprout. On the right the external surface of the tuber is seen with the characteristic wrinkling of the skin, and with several fungus pustules on the diseased portion.

2.—Two tubers, showing the association of the fungus with obvious wounds. On the left the wound is that of a spade; on the right the black spot indicates a hole made by the prong of a fork.



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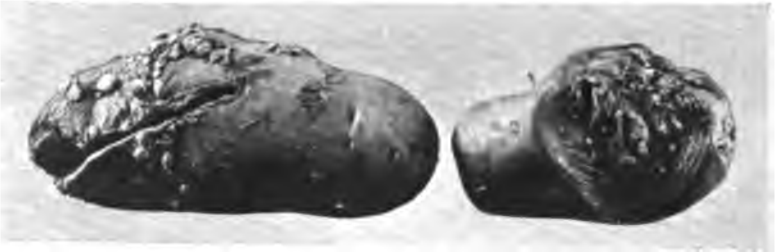

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XXIII.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1907.

By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Professor of Zoology in the Royal College of Science for Ireland, and Consulting Entomologist to the Royal Dublin Society.

(PLATES XLIX.-LIV.)

[Read, MAY 19; Received for Publication, MAY 22; Published, AUGUST 29, 1908.]

PARASITES OF DOMESTIC ANIMALS.

The Common Tick.

Ixodes ricinus (Linn.).

THIS well-known species, which is found on many of our domestic animals, is received every year from various parts of the country. It is found mostly on cattle, sheep, and dogs. In May, 1907, specimens were given me by Mr. J. Malcolm, D.L., of Lurgan, who had taken them from dogs. He told me that the ticks were very hard to exterminate, as they had the habit of sheltering in the cracks of the kennel-building between bricks, and infesting other dogs after an interval of some months. It is known that ticks can live without food for a considerable time between the various feeding stages of their life-history, so that the facts are readily explicable, but such a sheltering-place is probably unusual.

The most familiar form of tick is the adult female (fig. 1, *b*), swollen with blood and eggs, to be found attached to animals, usually at the base of the legs where the skin is delicate, and where the parasite cannot be removed by biting or licking. Attachment is secured by the jaws—chelicerae and labium—which are provided with barbed processes, making the forcible withdrawal of the piercing-beak difficult. The arrangement of these barbs varies somewhat in the labium of the two sexes. Besides its use as a feeding apparatus, the beak of the male is used in pairing, being thrust into the female's vulva (fig. 1, *b*, *v*) which is between the hindmost of the four pairs of legs. A female tick may be often found on cattle and dogs, with the comparatively small male (fig. 1, *a*), whose whole body is almost covered by the dorsal shield, clinging beneath. When she has gorged herself with blood from the host-animal, and her eggs have developed so that her leathery cuticle is enormously swollen, the female drops to the ground, and lays her eggs, 2,000 or more, among the herbage.

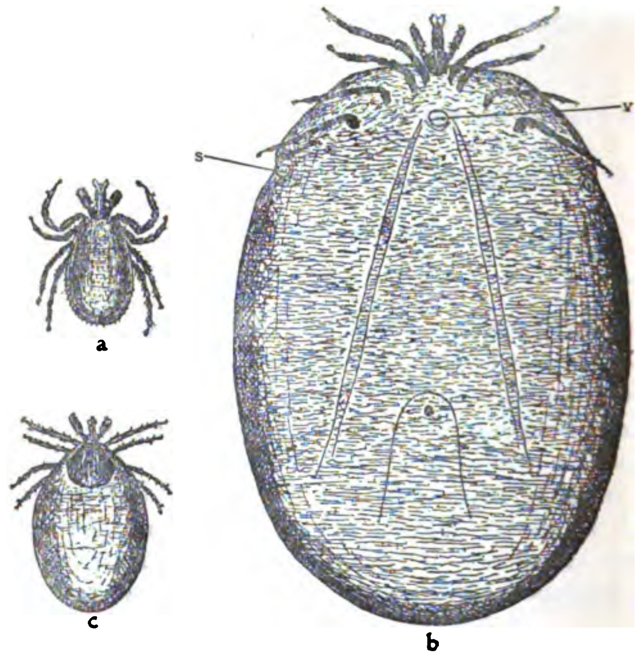

FIG. 1.—Common Tick (*Ixodes ricinus*) (*a*) male, dorsal view; (*b*) female, ventral view, swollen with blood and eggs: (*c*) nymph. Magnified 7 times.

From the eggs are hatched, about eight weeks after laying, the little six-legged larvæ or "seed-ticks," which crowd on the herbage, waiting for the chance of fixing themselves to some passing animal. If they succeed, they suck blood for a few days, and then fall off again. After a while they cast the cuticle, and become changed into eight-legged "nymphs." The nymph waits, like the larva, for some passing beast, and after another meal of blood (fig. 1, *c*) drops off, casts its cuticle, and assumes the adult condition. The adults wait in the herbage for a suitable host on which they pair, the females, as explained above, becoming greatly distended. Thus the life-cycle is completed. The time occupied depends on the interval during which the growing tick has to wait for a "host" animal. It may live without food for six months, or even a year.

The obvious damage done by ticks to the animals that they infest is the loss of blood caused by their sucking. But a more serious danger is, that in sucking blood they transmit blood-parasites—possibly the cause of fatal disease—from one animal to another. These parasites are minute unicellular animals belonging to the Protozoan class Sporozoa. A short account of recent researches on these organisms may be therefore advisable.

The Red-water Parasite.

Piroplasma bovis (Bates.).

The parasite of red-water is a micro-organism found in the blood of cattle and in the digestive tract of ticks. It is undoubtedly a unicellular animal, belonging therefore to the Pretozoa; and, like most parasitic Protozoa, it is a member of the class Sporozoa. All the Sporozoa are at some time intra-cellular parasites, living within a single cell of the host-animal. Piroplasma is most frequently observed within the red blood-corpuscles of the affected cattle. In its best known stage it is a minute, pear-shaped body, about ·003 mm. in length, and ·001 mm. in thickness (*i.e.* $\frac{1}{8000} \times \frac{1}{25000}$ inch.). Within the corpuscle the parasite changes its shape, becomes circular or amœboid, and finally divides in two, the two daughter-cells being often seen still attached by their narrow ends; hence the specific name *bigeminum*

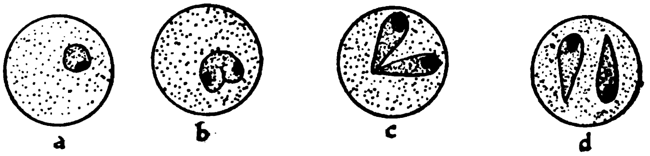

FIG. 2.—*Piroplasma bovis* in red corpuscles of bovine blood. Magnified 900 times, (*a*) amœboid form; (*b*) division; (*c*) bigeminate form; (*d*) separation of "twins."

often applied to the species. The multiplication of the parasites causes the red corpuscles to break down ; the parasites then become free in the plasma and invade other corpuscles, whose numbers thus become vastly reduced, while the red-colouring matter (hæmoglobin) diffused in the plasma is usually excreted by the kidneys.

Blood sucked by a tick from an infected cow or calf contains, of course, a large number of the minute parasites. It has been known for some years past that Piroplasma in the digestive tube of an adult female tick can give rise to infection in the offspring of that female, so that one generation of ticks can acquire the parasites from cattle, and the next generation can transmit the disease to other cattle. (See Mettam, 14.)

Further researches are needed as to the development of the parasites in the two generations of ticks. Several authors have made observations whose correctness is doubted by other authorities. According to the recent work of Christophers (9) on the Sporozoan blood-parasite of the dog (*Piroplasma canis*), the parasites drawn into the stomach of the blood-sucking female tick enlarge there, and then, perhaps after conjugation, they constrict to form vermicular, club-shaped bodies, which migrate from the digestive tract to the ovaries. There they enter the ova and enlarge to a diameter of ·0025 mm., forming "zygotes." As the development of the tick proceeds, the zygotes divide to form sporoblasts in the embryonic and larval tissues. Finally the sporoblasts give rise to motile sporozoites which are collected in the salivary glands. Hence they can be injected into the blood of the vertebrate host on which the larval tick may fix itself. It is likely that the development of *Piroplasma bovis* in the tick is similar to this.

In any case we know that the long-continued existence of *Piroplasma bovis* in a district depends on the presence of its two host-animals—the ox and the tick. In this country the life-cycle of the ticks is so irregular with regard to the season of the year, that their extermination must be regarded as impracticable. But by keeping cattle off land where red-water has been prevalent, it may be possible—as suggested by Mettam (14)—to prevent ticks from getting a fresh supply of Piroplasma, and thus by stopping the life-cycle to protect cattle that may be admitted to the once infested pastures after the offspring of the latest generation of Piroplasma-bearing ticks are all dead. The difficulty of stamping out the disease in this way lies in the fact that cattle reared in "red-water" districts become immunised by successive injections of the parasite when bitten early in life by infected ticks; and there is reason to believe that immune animals may harbour the Piroplasma for several years.

Scab and Itch Mites.

Psoroptes communis, Furst, *Chorioptes bovis* (Gerl.), and *Sarcoptes scabiei* (Linn.).

During the year specimens of all these three common genera of parasitic mites were received from various parts of Ireland. The various forms of "mange" or "scab" produced by their presence are well known, and appropriate treatment by "dips" or "washes" is described in veterinary writings. As the recognition of these genera is often practically important, it is advisable to give here a short systematic account of them.

All three are members of the family Sarcoptidæ, which includes very small mites with wrinkled cuticle, piercing jaws, and suckers on the feet; these secure attachment to their hosts, as all are parasites on various vertebrate animals. They have no spiracles, or air-tubes, but they breathe all over the surface of the body.

Commonest, and most important of the three, is Psoroptes, the true scab-mite. It has usually been stated that the Psoroptes found on various domestic animals all belong to one species, *P. communis*, but the forms on horse, ox, and sheep, are recognized as distinct species by Kramer and Canestrini (6), an opinion perhaps warranted by the fact that mites from one of these domestic hosts cannot infect another. The genus Psoroptes is readily distinguished by the presence of three segments on each foot of the first and second pairs of legs in both sexes (fig. 3). In the female the legs of the third pair do not terminate in typical feet, but each bears two exceedingly long slender bristles. The male has the third pair of legs normal, but the fourth are very short, with a vestigial foot of a single segment only. The female (fig. 3, *b*) mite is oval in form; the male (fig. 3, *a*) more rotund, with paired, circular suckers near the hinder end, and a pair of prominent subcylindrical processes, which carry elongate bristles. The mites are about ·5 mm. (·02 inch) in length. Each female Psoroptes

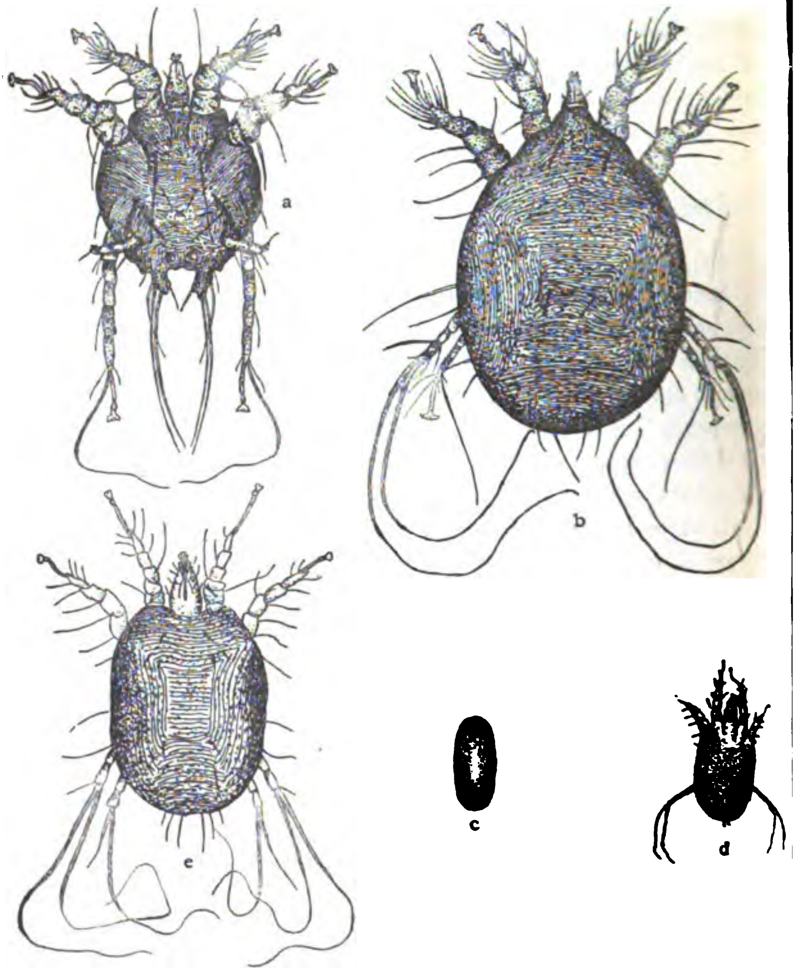

FIG. 3.—Scab-mite (*Psoroptes ovis*)—(*a*) male, ventral view × 70; (*b*) female, dorsal view, × 70; (*c*) egg, × 180; (*d*) larva, × 180; (*e*) nymph, × 180. After Salmon and Stiles. Bull. 21, U. S. Dept. Agric. (Anim. Ind.).

lays about twenty eggs (fig. 3, *c*), which are attached to the skin or wool of the sheep. The tiny, six-legged young (fig. 3 *d*) are hatched in about a week, and after a short four-legged "nymph" (fig. 3, *e*) stage, develop in ten days into adults capable of pairing and laying eggs in their turn. The rate of multiplication is, therefore, enormous, and mites and eggs can live for several weeks after removal from sheep. Thus fences, hurdles, posts, and such structures can become centres of infection, while birds carry mites from scabby to healthy sheep. They attack the hairy parts of the skin, which they pierce with their barbed jaws, causing great irritation, bleeding, and the discharge of serous fluid, which hardens to form the crust or scab beneath which the mites shelter. As a result of their presence, the wool becomes matted and soiled, and falls off. (See Salmon and Stiles, 17.)

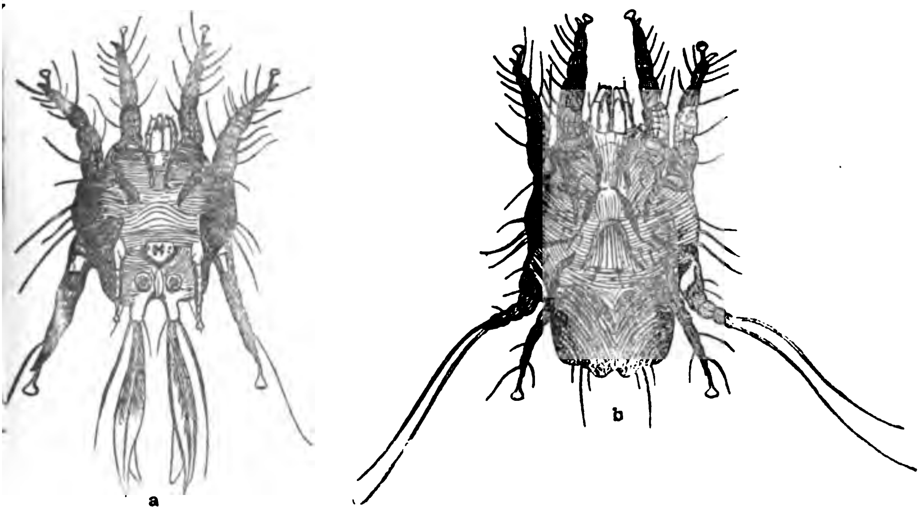

FIG. 4.—Mange Mite (*Chorioptes bovis*).—(*a*) male, ventral view, × 75; (*b*) female, ventral view, × 75. In part after Neumann.

Chorioptes resembles Psoroptes in general aspect, and the male (fig. 4, *a*) has a pair of short, bristle-bearing processes at the hinder end of the abdomen. The legs in this genus are relatively shorter and stouter than in Psoroptes, and the foot consists of a single segment only (fig. 4). These mites are found on the less hairy parts of their hosts' bodies. They caused much trouble on cattle in County Dublin and elsewhere during the summer of 1907, and the infection could, in the cases that came under observation, be traced to a single centre.

The Itch Mite (*Sarcoptes scabiei*) is easily recognized (fig. 5) by its rotund form, and its very short, stumpy legs; each foot consists of one long segment only, but in the third pair of legs in the male, and in both third and fourth pairs in the female, this sucker-foot is replaced by a long, curving bristle. Itch Mites differ in habit from both Psoroptes and Chorioptes by burrowing into the skin. Within these burrows the female lays her eggs, from which the young are hatched; when fully grown, they make their way out to the surface of the skin, where they pair, after which the females burrow to lay their eggs. On account of their burrowing habits, the Itch Mites are very difficult to eradicate. Dressing and dips for these, and also for Psoroptes and Chorioptes, are prescribed in works on veterinary practice. The attack of sarcoptic mange that was brought to my notice in 1907 was cured by the use of a corrosive sublimate wash—one part of the poison to 400 parts of water. This apparently soaked into the skin and killed the mites in their burrows without injury to the health of the affected cattle. The presence of Sarcoptes on cattle is evidently unusual, as no "*Sarcoptes bovis*" is mentioned in the recent work of Canestrini and Kramer (6).

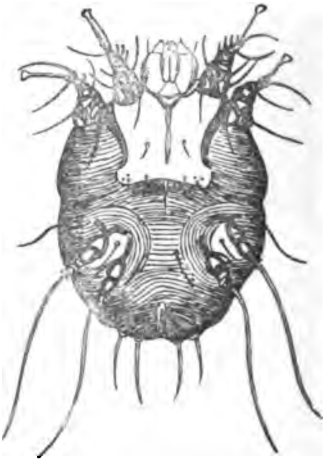

Fig. 5.—Itch Mite (*Sarcoptes scabiei*).—Ventral view of female, × 270.

CORN INSECTS.

The Ghost Swift Moth.

Hepialus humuli (Linn.).

Caterpillars of this well-known insect were sent in February from County Down, through the Editor of the *Farmer's Gazette*; they had been found in numbers in "lea ground for oats." An account of the species has been already given in a previous paper of this series (7, pp. 95–97). It is of interest that on this occasion the observer wrote: "Very few that are on or near the surface after the plough escape the birds."

The Common Rustic Moth.

Apamea didyma Esp.

(Plate XLIX.)

An interesting feature of the year was the presence of caterpillars of this common noctuid or "owl-moth" feeding within the base of the sheathing-leaves of barley and oats. Except for a mention of the species by Curtis (10, p. 225) as injurious to wheat, and a recent observation by Theobald (18, pp. 70–1) of its presence in Cocksfoot grass, I know of no record of the insect in economic literature.

The caterpillar was first noticed in May, 1906, by Mr. H. Hunter, of the Department of Agriculture, in the experimental barley plots at the Albert College, Glasnevin. Some of the young shoots were seen to be yellow and withered, and, on examination, such shoots were found to have been eaten at the base by the caterpillar, which sheltered in the hollow of the stem or within the sheathing-leaves. As in the case of the wheat recorded by Curtis, the caterpillar works downwards towards the roots. I was unable to identify or to rear the caterpillar in 1906. In May, 1907, however, it was found again damaging the barley in the same manner, and, towards the end of the month, I received from Mr. R. M. Barrington, of Fassaroe, Bray, County Wicklow, young oat-plants, which were attacked in just the same way by the same species of caterpillar. On offering some of the caterpillars

Cocksfoot grass (*Dactylis glomerata*), I was satisfied to see that they fed on it quite readily, working their way downwards to the base of the shoot, just as in the barley or oats. One of the caterpillars pupated on June 18th, and on July 25th there emerged a dark specimen of *Apamea didyma* (*oculea* Guen.).

This moth, one of the commonest of our native Noctuidæ, is exceedingly variable in colour and markings. The fore-wings may be reddish-brown, drab, or blackish, sometimes mottled all over with darker scaling, sometimes traversed by a dark, central, angulated band. Usually there is a conspicuous ovoid mark ("reniform stigma"), white, yellow, or pale-brown in colour. The hind-wings are dark-brown. The moth flies after dark in July and August, usually sheltering during the day among grass and other vegetation (Barrett, 1, pp. 391–6).

The caterpillar is variable in colour—usually some shade of green, the head, and a semicircular plate on the tail-segment, being brown. There are reddish dorso-lateral lines, sometimes very faint, and the spiracles are black. The eggs are laid in autumn, and the young caterpillars are hatched before winter, feeding on various kinds of grasses. There can be no doubt that in the cases now described the caterpillars had made their way from grasses to the growing cereals. This fact in the life-history suggests possible modes of preventing damage by the insects, by digging up the grassy "headlands" round cornfields. The concealed mode of feeding adopted by the caterpillar makes any remedial dressing impossible.

CLOVER, CABBAGE, AND MANGOLD INSECTS, &c.

Stem Eelworm.

Tylenchus devastatrix, Kuhn.

Some clover plants attacked by these well-known pests were received in November, from Mr. J. M. Adams, Agricultural Instructor for Co. Cork. Their presence caused the clover to "sicken," becoming black and dry over numerous patches in the field. The life-history and habits of these worms in connexion with an attack on oats have been discussed in a former paper of this series (7, pp. 285–8).

The Cabbage Fly.

Phorbia brassicæ, Bouché.

As usual, attention was drawn to the presence of the maggots of this fly (7, pp. 141–4) both in the north and south of Ireland. At one locality in Co. Dublin, during July, besides tunnelling the roots in their usual manner, the maggots ate cabbage plants right through the base of the stem.

"Turnip-flies."

Phyllotreta consobrina, Curtis, and *P. nemorum* (Linn.).

(Plate L., B.)

Specimens of the flea-beetle *Phyllotreta consobrina* were received in June, from Stillorgan, Co. Dublin, where they were devouring cabbages. So far this species has only been noticed in Ireland in this county (see Johnson and Halbert, 12, p. 771); but it occurred here in sufficient numbers eight years ago to be seriously injurious to cruciferous crops, as again last year. It belongs to the same genus—Phyllotreta—as the common "Turnip-fly" (*P. nemorum*). As is well known, this genus belongs to a section of the Chrysomelidæ (leaf-beetles), in which the thighs of the hind-legs are remarkably large and thick, so that the insects jump with great agility, and have come to be known as "flea-beetles." The species of Phyllotreta are small beetles of elongate oval form, the cavities of the front haunches open behind, the punctures on the wing-cases not arranged in linear striæ, and the pronotum without a transverse impression.

P. consobrina (Plate L., B, 2) is one of the dark, unicoloured species of the genus, the upper surface being blackish, with a blue or green reflection, very closely and rather strongly punctured; the feelers and the legs are all black. The insect measures from 2 to 2·5 mm. ($\frac{1}{12}$–$\frac{1}{10}$ inch) in length. *P. nemorum*, like *P. undulata*, Kutz, another species which is sometimes injurious, has a conspicuous, yellow, longitudinal stripe on each wing-case. In *P. nemorum* (Plate L., B, 1), this stripe is waved in the middle, the basal segments of the feelers are light yellow, and the shins of all the legs are reddish-yellow. *P. nemorum* is rather larger than *P. consobrina*, being from 2·5–3 mm. ($\frac{1}{10}$–$\frac{1}{8}$ inch long). (See Fowler 11, vol. iv., pp. 361–6.)

The habits and life-histories of these "Turnip-flies" are well known to all. *P. nemorum* is common everywhere in Ireland, and its yearly appearance is so familiar that but little attention is paid to it. The insects pass the winter in the perfect state and come out of their shelters in early spring to lay eggs on cruciferous plants. Until the turnip and cabbage seedlings are ready, they content themselves with charlock and other weeds belonging to the Cruciferæ. The white, caterpillar-like larvæ, with three pairs of thoracic legs, and a chitinous plate with a pair of spiny processes at the tail-end of the abdomen, mine in the green tissues of the leaves. The transformation is completed in about three weeks, and the beetles feed greedily on the leaves from outside. Contrary to the general rule, the greatest damage is done by these beetles in the adult, and not in the larval, stage. Successive generations appear through the summer, often with disastrous results to crops, especially in dry seasons.

Many suggestions for checking the ravages of "Turnip-flies" have repeatedly been made, such as dusting with lime and soot, knocking off the beetles with brushwood or mechanical appliances, or catching them on tarred boards. None of these can be recommended with any confidence. Thick and early sowing, and the clearance of cruciferous weeds, are obvious preventive measures. Some years ago statements were made (see 7, pp. 140–1) as to the success of spraying with the "Bordeaux mixture" (copper sulphate and lime) at half the strength used for spraying against potato-blight. Careful experiments with this would be well worth trying; and in bad attacks, farmers should certainly try the effect of spraying with lead arsenate, which would probably not fail to kill the beetles, and, if applied with care, could be used without danger to man or beast.

Ground Beetles.

Pterostichus cupreus (Linn.) and *Taphria nivalis*, Panz.

(Plate L., c.)

That certain species of the carnivorous family Carabidæ often devour mangold plants, cutting them through at the ground-level, has long been known. An account with figures of these species—*Peterostichus madidus*, Fab., *P. vulgaris*, Fab., and *Harpalus ruficornis*—has been given in a former paper (7, pp. 150–1). In June, 1907, mangold plants, eaten through, were received from Rathnew, County Wicklow, together with specimens of two other species of ground beetles (Carabidæ), viz.: *Taphria nivalis*, Panz. and *Pterostichus cupreus* (Linn.). *P. cupreus* (Plate L., C, 1) is a smaller beetle than *P. madidus* or *P. vulgaris*, being 10–12 mm. (less than $\frac{1}{2}$ inch) long, and it is usually green, bronze, coppery, or purple in colour, though occasionally black like those species. Its feelers are black with the two basal segments red, its pronotum sub-quadrate with broad, rounded margins, and its legs black. It is a common beetle throughout Ireland.

Taphria nivalis (Plate L., C, 2), is the only Britannic species of its genus, which is characterized by the comb-like teeth on the foot-claws, the rounded sides of the pronotum, and the long, oval wing-cases. Taphria agrees with Pterostichus in having three segments of the fore-foot broadened in the male. *T. nivalis* is a shining pitch-black species, 6–7 mm. ($\frac{1}{4}$–$\frac{5}{16}$ inch) long; the feelers, palps, and legs are red, and the edges of the pronotum may be reddish. It has a wide distribution in Ireland, and is common in the more hilly districts (12, p. 577).

Probably the method of trapping by sunken tins or jars baited with putrid meat, that has been found effectual against the larger species, would also be the best means of destroying these.

The Bright-line Brocade Moth.

Mamestra oleracea (Linn.).

(Plate LI., D.)

The conspicuous striped caterpillars of this moth were received in October, from Counties Waterford and Cork, with the information that they were causing much damage to crops of mangold and turnip. I am indebted to Mr. J. Johnston, County Instructor in Agriculture, for a full account of some observations on the habits of the insects in Waterford. This, although a very common caterpillar, has not, I believe, been previously noticed as injurious to any farm crop; the occurrence is therefore noteworthy.

Mamestra oleracea is one of the Noctuidæ or owl-moths. It is easily recognized by its dull purple-red fore-wings, each with a conspicuous orange spot on the disk, and a distinct white subterminal line, which is produced in the middle to the margin, somewhat in form of the letter W; the hind-wings are dusky-whitish. The moth flies in June and July, and may be commonly seen at dusk in gardens and fields, and on grassy banks; it usually hides by day among plants or on walls and fences. (Barrett, 1, p. 187.) It measures from 35–40 mm. (1⅖–1⅗ inches) across the wings. The caterpillar, hatched from eggs laid at midsummer, becomes fully grown in autumn. The caterpillars are variable in colour—brown, pink, green, or yellow, always with white mottling, and with a very distinct and conspicuous yellow stripe in the region of the spiracles. They feed on a great variety of plants, but especially on goosefoot, nettle, dock, and sallow.

Usually these caterpillars are fully grown by the end of September; but last year they continued to feed through October, and it was then that they caused so much damage to mangolds and turnips. In one field near Dungarvan the mangolds were almost stripped of leaves, and everywhere they were eaten into holes. The glossy black pupa lies underground from October till June in a cocoon of earth and silk; appropriate winter treatment of the land may, therefore, be expected to destroy many of the insects in that stage. Mr. Johnson suggested scarifying the surface after the crop has been gathered, so as to expose the pupæ to birds and frost, or ploughing with a skim-counter, so as to bury them deeply, or dressing with a mixture of lime and salt, 10 cwt. lime and 5 cwt. salt to the acre.

POTATO AND PARSNIP INSECTS.

Potato Flea-beetle.

Psylliodes affinis, Payk.

Potato-leaves eaten by these beetles, already described in a former paper (7, pp. 254–5), were received early in June from Newcastle, County Down.

Potato Stem-borer.

Gortyna ochracea, Hb.

The habit of the caterpillar of this moth, feeding in stems of potato, has already been described (7, pp. 253–4). A specimen was received from Ferns in May last year.

The Carrot-fly.

Psila rosæ (Fab.).

Parsnips from Navan, County Meath, were handed to me in February, by Dr. G. H. Pethybridge; the roots were eaten by the well-known maggots of this fly (7, pp. 255–7). We have here a a good illustration of how these insects continue to feed through a mild winter.

TOBACCO INSECTS.

The cultivation of a new exotic crop, like tobacco, in Ireland, affords interest to the biologist in the observation of certain of our native insects which may be attracted to feed on it. During 1907 there were plots of tobacco in various districts of the country; and I am indebted to Mr. G. W. Keller, the American expert of the Department of Agriculture, for the opportunity of examining a number of insects observed by him.

Cabbage and Bright-eye Moths.

Mamestra brassicæ (Linn.) and *M. oleracea* (Linn.).

(Plate LI., D, E.)

During August and September, caterpillars of the Bright-eye Brocade Moth (*Mamestra oleracea*) and of its well-known congener the Cabbage-moth (*M. brassicæ*) were noticed eating tobacco plants in County Cork. Only a few plants were attacked, but the leaves of those were very badly eaten. *Mamestra oleracea* has already been described above (p. 572) in connexion with the ravages of its caterpillar on mangold. *M. brassicæ* (Plate LI., E) has a very similar life-cycle, the moth being on the wing from June till August, the caterpillar feeding till September, and the buried pupa being the wintering stage. The moth has blackish-grey forewings with white discal spots, and a toothed whitish subterminal line. It measures 33–43 mm. (1⅓–1¾ inches) across the outspread wings. The caterpillar is brown or green, with dark dorsal line, often with paired, black longitudinal marks at the hinder end, and there is a yellowish lateral line below the spiracles; this is the caterpillar that is not infrequently boiled with cabbage. The most effective way of combating these moths is evidently to destroy the wintering pupa.

Wireworms.

Agriotes sp., &c.

(Plate LII.)

The larvæ of Agriotes—the "Wireworms"—so destructive to all kinds of crops in this country—have already turned their attention to tobacco. Seedlings badly eaten by these, and by the larvæ of some other Elaterid or "Click-beetle," were received from County Cork in July. It is evident that all care should be taken to clear land intended for tobacco from Wireworms, as far as possible, by the usual well-known methods. Those who use "Vaporite" against Wireworms should remember that, as it must be dug into the soil to be effective, it can only be used before sowing or planting out.

A New Irish Springtail.

Isotoma tenella, Reuter.

At the end of April Mr. Keller sent me, from Kilkenny, tobacco seedlings, the leaves of which were covered with multitudes of small, dark-greyish Springtails or Collembola. Reference to the root-feeding habits of the lowly wingless insects of this order has been previously made in this series of papers (pp. 251–3). On the present occasion the species was eating the leaves, whose surfaces showed distinct abrasion, while the digestive tracts of the springtails contained chloroplasts. The springtail was clearly an Isotoma—a genus distinguished by the close equality in length of the third and fourth abdominal segments; by the absence of scales on the cuticle; by the presence of a well-developed spring; and by the simple nature of the characteristic post-antennal sense-organ (fig. 6, 2). But the species had never been recognized before, either in Ireland or in Great Britian, so that we had, as occasionally in previous cases, an addition to our fauna forcing itself on our attention by damaging cultivated plants. It proved to be *I. tenella*, Reuter, first described from Finland, and recently noticed in Germany. There can be little doubt that the species is truly indigenous in Ireland, and that the new food-plant—in shape of the tobacco seedlings—incited it to increase enormously in numbers in one particular locality.

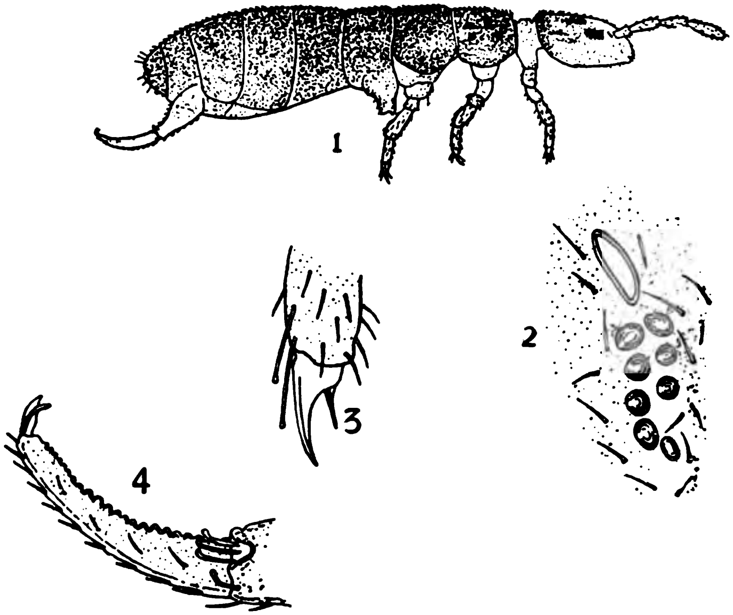

Fig. 6.—*Isotoma tenella.* (1) side-view of insect, x 75; (2) left-ocelli and post-antennal organ, x 500; (3) hind-foot, x 500; (4) dens and mucro of spring, x 500. From Carpenter, *Irish Naturalist*, vol. xvii.

Isotoma tenella is easily recognized by the foot with simple claw, with very narrow tapering empodium, and with two tenent (clubbed) hairs (fig. 6, 3), and by the characteristic mucro (claw) at the end of each branch of the spring with its two teeth (fig. 6, 4). Like most species of Isotoma, *I. tenella* has eight simple eyes (ocelli) on each side of the head; its post-antennal organ is somewhat broadly ovate in form. The insect measures only 1 mm. ($\frac{1}{25}$ inch) or slightly more in length.

Although these springtails appeared to find tobacco-leaves a very satisfactory food, Mr. Keller succeeded in killing them in numbers with a nicotine fumigator.

ORCHARD INSECTS.

The Gooseberry Sawfly.

Nematus ribesii (Scop.).

Caterpillars of this well-known insect, described and figured recently in this volume (7, pp. 335–7), were received from Cork on May 21st. Some of them pupated immediately; and a number of flies—all females—emerged between the 6th and the 10th June.

The Winter Moth.

Cheimatobia brumata (Linn.).

This familiar and destructive insect has also been recently described (7, pp. 329–31). Its young caterpillars were sent from Cork by Mr. J. M. Adams, on May 10th. They had been feeding on the blossoms, so as to prevent the setting of the fruit. On May 23rd, blossoms eaten by the caterpillars were received from County Armagh. Early in June, caterpillars of the same moth were received from Antrim. These had been feeding in a manner unusual for the species—boring into gooseberries ripening on the bushes, so as to tunnel and disfigure them badly.

The Pith Moth.

Blastodacna vinolentella (Herr.-Schäff.).

This is another species of moth recently (7, pp. 333–4) dealt with in these reports. A pupa in a bored apple-twig was observed in July, at Glasnevin.

Common Vapourer Moth.

Orgyia antiqua (Linn.).

(Plate LIII., G.)

Twigs of apple with cocoons and egg-masses of this insect were received from County Clare in February. It belongs to the family of the Lymantriidæ, characterized by the strongly pectinated feelers of the male, the vestigial condition of the jaws in the moth, the presence of a dense hairy covering on the caterpillar, the hairs being frequently arranged in tufts or "tussocks," and a thin hairy coat on the pupa. The male of *O. antiqua* measures from 25 to 30mm. (1–1¼ inches) across the outspread wings, which are yellowish-brown in colour, traversed by darker lines, and showing a conspicuous white spot near the hind corner; the hind-wings are deep orange-brown. The moth may be observed flying around trees in September and October. The female is a stout, brown, hairy insect, with short, feeble feelers and legs, and her wings greatly reduced, so that, of course, she cannot fly. She merely emerges from the dense cocoon on the food-plant, in which the pupal-stage has been passed, and, after pairing, lays her eggs in a mass on the cocoon. These eggs remain unhatched through the winter, and the species is often spread to new localities by young trees on which are egg-clusters being planted in late autumn. The little, hairy caterpillars are hatched in April and May. They feed greedily on the leaves of many different trees—notably Rosaceæ—and become fully grown in August. Then the caterpillar is from 1 to 2 inches long, greyish, with a black dorsal line and red spots, adorned with whitish hairs, and furnished with a series of dorsal "tussocks," either black or yellow, black on the first thoracic and eighth abdominal segments, yellow on the first, second, third, and fourth abdominal; there are also lateral tufts of black hairs on the first thoracic and second abdominal segments. When full-fed the caterpillar makes a rather dense cocoon of silk and its own cast hairs, within which the pupal stage, lasting only a few weeks, is passed. The caterpillars are very active, sometimes migrating in search of fresh food-plants. This habit is useful for the extension of the insect's range, as the female cannot fly.

Spraying with lead-arsenate wash poisons the caterpillars, against which emulsions are of little or no use. The clearance of the cocoons with the attached eggs in winter should be carried out wherever practicable.

The Eyed Hawk-moth.

Smerinthus ocellatus (Linn.).

The large caterpillars of this handsome moth attract attention in some years by the damage that they do to apple foliage. During 1907 specimens of them were sent by two of the County Horticultural Instructors—Mr. P. R. Farrelly, of Kildare, and Mr. P. J. Callan, of West Cork. The insect is a well-known member of the Sphingidæ (Hawk-moths), large, robust moths of powerful flight, with elongate fore-wings and shorter hind-wings, spindle-shaped feelers, and long, flexible proboscis. *Smerinthus ocellatus* measures from 75 to 90 mm. (3–3½ inches) across the outspread fore-wings, which are pale-reddish brown, with darker brown markings; the hind-wings are reddish, each with a blue-ringed eye-spot, which gives the name to the species (fig. 7, 1). The moths are on the wing in May and June; the caterpillar appears in

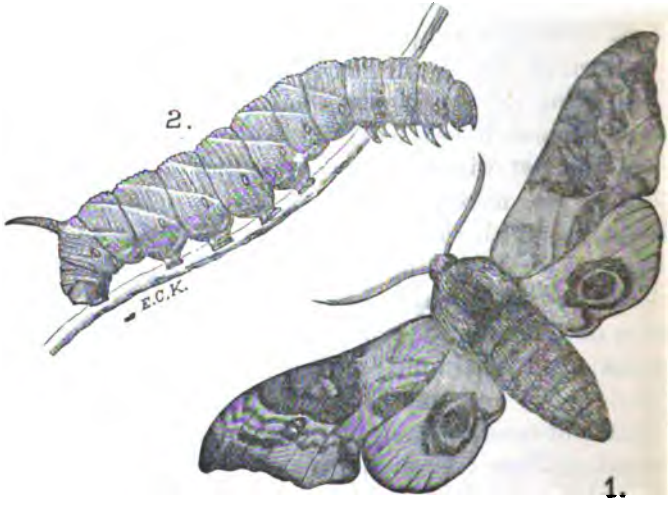

FIG. 7.—Eyed Hawk-moth (*Smerinthus ocellatus*) and its caterpillar. From Ormerod's "Reports."

July. When fully grown it is green, with a series of slanting white lateral stripes, and red spots. As in most sphingid caterpillars, there is a conspicuous "horn" on the eighth abdominal segment; and in the present species this horn is blue, whereas in the nearly allied *S. populi* it is yellowish-green.

The caterpillar (fig. 7, 2) of *S. ocellatus* feeds on poplar and various kinds of sallow, as well as on apple. Mr. Farrelly noticed in Kildare that the larvæ ate the tender leaves close to the stem. Mr. Callan stated that near Clonakilty there were usually two or three caterpillars on each tree, and that they fed most vigorously in close, showery weather, sometimes defoliating a small tree in a few days. Hand-picking is the simplest and surest remedy. The caterpillar is fully grown in September, towards the end of which month it usually pupates in an earthen cell in the ground; thus it passes the winter.

Weevils.

Otiorrhynchus sulcatus, Fab., and *O. picipes*, Fab.

These well-known beetles were received in May from County Wexford, where the clay-coloured species (*O. picipes*) was reported as very destructive to the foliage of pear-trees. The true weevils form a large family (Curculionidæ) of the beetles (Coleoptera), easily recognized by the elongation of the head into a beak or snout, at the end of which are the jaws, the elbowed feelers being inserted at the sides of the snout near the tip. In the genus Otiorrhynchus the snout is swollen at the tip, and its scrobes[1] or furrows are on the upper surface, not at the sides; the feelers have an elongate scape, and the thighs are club-shaped and often toothed. *O. sulcatus*, the larger of the two species, is 9–10 mm. (about $\frac{2}{5}$ inch) long, black and shining in colour; the elytra, with deep furrows, and coarsely granulated, are without scales, but with tufts of yellow hairs, and the front thighs are distinctly toothed. *O. picipes* measures only from 6·5 to 8 mm. (about $\frac{3}{10}$ inch) long; its elytra have a covering of small round scales and ashy hairs, its legs are red or pitchy-red, and the tooth on the front thigh is indistinct (fig. 8, 1, 5).

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[1] See Fowler (11) vol. v., pp. 178-9.

The larvæ of Otiorrhynchus (fig. 8, 3, 6) are white, fleshy, rather hairy grubs with much wrinkled cuticle, and hard, brown heads provided with strong mandibles. They lie curled up in the earth, eating the roots of plants. The eggs are laid in the ground by the parent beetle late in the summer, and the grubs feed and grow until the spring of the next year, when they pupate. The beetles eat leaves and blossoms, and at times gnaw the bark of orchard trees, and of many garden and greenhouse plants, so that, as the larvæ eat roots, a double toll is levied on the plants by the two stages of the insects' life-history. Raspberries and vines are especially subject to the attacks of the beetles, which feed by night, hiding by day beneath clods or stones.

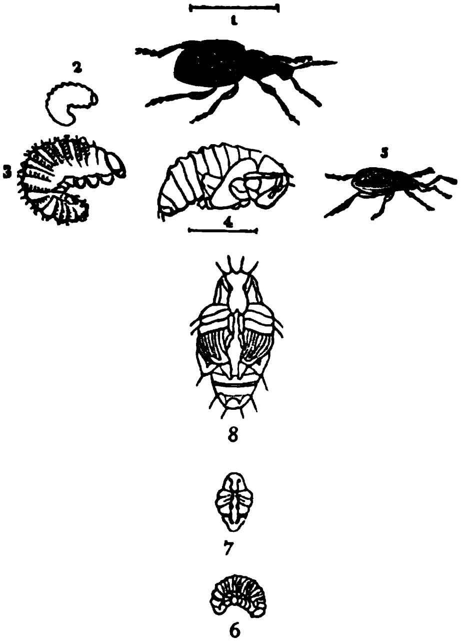

Fig. 8.—1 *Otiorrhynchus sulcatus*, enlarged; 2, 3, its larva, natural size and magnified; 4, its pupa, magnified; 5, *O. picipes*; 6, larva; 7, pupa, natural size; 8, pupa, magnified. From Ormerod's "Reports."

This feature of their habits enables us to stop their ascent to the trees and bushes by sticky bands, or by lime placed around the trunks or stems. In the case of trees against walls, the walls should be well pointed and whitewashed, and a layer of lime placed along the bottom. At night, with a lantern, it is easy to shake the weevils down on to sheets or tarred boards, so that they may be destroyed. Spraying with arsenate of lead may be tried in the worst cases.

The Black Currant Mite.

Eriophyes ribis (Westwood).

A description of this mite, of which examples are received every year from various localities, has been previously given (7, pp. 260–2). Very contradictory reports have been given as to the effect of dusting with lime and sulphur, as recommended by Collinge (see 7, p. 441). On the whole, it must be admitted that such dusting cannot be relied on to prevent the migration of mites from old to new buds. Some interesting notes on the habits of the species were published during 1907 by Massee (13), who regards the upright position assumed by the migrating mites as a preparation for pairing. He states that when a mite is in the upright posture, "if another mite approaches, the two come in contact, . . . apparently a sexual act." Massee found that he could stop the access of the mites to healthy buds by vaseline bands around the twigs, and that painting the big buds with vaseline prevents the escape of the mites from their old habitations. Sticky substances, such as cart-grease or palm oil, applied with a brush to infected bushes, were found to answer practically; the painting of individual buds and twigs would, of course, be impossible on a large scale.

The Pear-leaf Blister Mite.

Eriophyes pyri (Nalepa).

Pear-leaves with the characteristic blisters caused by these mites were received from Co. Dublin, both north and south of the city, during May and June. The mite which causes this deformation is, like the Currant Mite, a small elongate creature, with only two pairs of legs. It measures only ·2 mm. ($\frac{1}{125}$ inch) in length, and is relatively stouter and with more elongate rostrum than the Currant mite. Leaves infected with these mites are covered with little rotund blisters—at first green or red, afterwards black or brown in colour. The blisters appear raised on both surfaces of the leaf, and a small central hole, leading into the cavity of the blister, is evident on the lower surface.

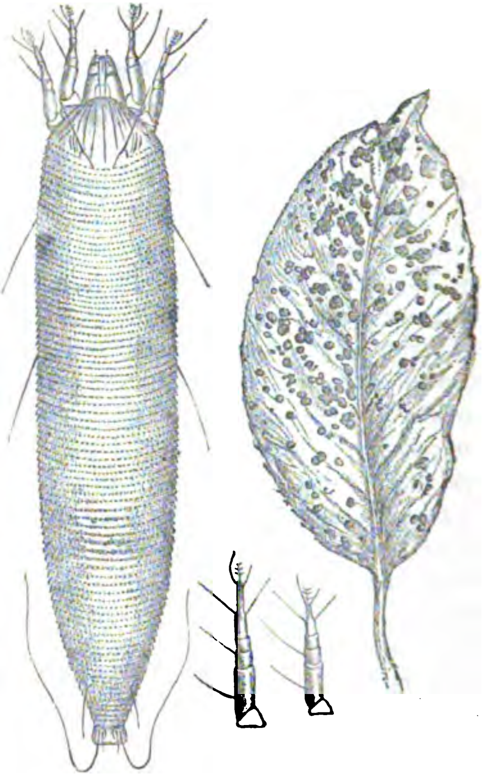

Fig. 9.—*Eriophyes pyri*, highly magnified, its legs more highly magnified (after Nalepa), and blistered pear-leaf, natural size. From Ormerod's "Reports."

It is known that the mites spend the winter "in the leaf and flower-buds of the one-year-old twigs, embedded in the felt-like layer of hairs on the inside of the outer bud-scales" (Ormerod. 15, p. 129). From these shelters they come out in early spring and attack the opening leaves, their presence in which is soon shown by the appearance of the blisters described above. Within the blisters they breed and lay eggs, and the young mites make their way out of the central hole below the leaf to invade the tissues elsewhere and form other blisters. Thus multiplication goes on through the summer, and before the fall of the leaf the mites seek the shelter of the winter buds.

Spraying with paraffin emulsion—as strong as can be safely applied to the foliage—checks the migration of the mites and the spread of the blisters. Strong spraying in winter is recommended as a preventive.

HAWTHORN INSECTS.

The Small Ermine Moth.

Hyponomeuta padellus (Linn.).

An account of this insect was given in my paper of last year (7, pp. 436–7), and reference was made to the damage done by the caterpillars to Hawthorn hedges in Co. Waterford. In June and July, 1907, Mr. J. Johnston, the County Agricultural Instructor, informed me that they were again most destructive to the hedges of a farm at Kilmacthomas, belonging to Mr. E. Flahavan, who wrote that on some of the hedges not a single leaf remained, and that he hoped for the starvation of the caterpillars as a result.

While this paper is in press, I have heard from Mr. Johnston of the good effects this summer of spraying with lead arsenate wash. No result was seen for some days; but three weeks after the spraying, only one live caterpillar could be found, and Mr. Johnston noticed hundreds of dead specimens.

FOREST INSECTS.

The Pine Sawfly.

Lophyrus pini (Linn.).

An account of this insect was given in my paper of last year (7, pp. 447–8). At the end of September, 1907, I received caterpillars of the species from Mr. E. W. Holt, who told me that they had been very destructive to Scots and Austrian Pine at Oranmore, Co. Galway. A few of these caterpillars pupated, and male flies have emerged during the present month (May, 1908).

A new Larch Sawfly.

Nematus maculiger, Cameron.

(Plate LIII., H.)

In December, 1906, Mr. W. B. Bruce handed me some sawflies of the genus Nematus, which had been identified for him by the English Board of Agriculture as *N. maculiger*, Cameron. He had taken caterpillars off the top shoots of young Japanese larches (*Larix leptolepis*) in Lord Ardilaun's grounds, St. Anne's, Clontarf, on July 5th, 1905. The caterpillars spun cocoons a few days later, and the flies emerged on April 29th, 1906. As Cameron, in his description of *N. maculiger* (5, pp. 118–119), states that the larva feeds on willow, I delayed publishing any record of the species until I had sent one of the specimens to Mr. F. V. Theobald, who, after kindly comparing it with Cameron's type in the British Museum, informs me that he considers it referable to *N. maculiger*. We must conclude, therefore, that the species is not confined to one type of food-plant. The specimen (Plate LIII., H) which I have before me, presented by Mr. Bruce to the National Museum, is a male, almost entirely black above, with the legs clear yellow and no black on the hind shins and feet. In Cameron's description, it is stated that there is variation in this character in different specimens. The occurrence of the species in Ireland is of interest, as Cameron states that it is a rare and local insect, recorded from the Clyde district, Worcester, and Sweden.

The Spruce Aphid.

Chermes abietis, Kalt.

The characteristic galls of this aphid were sent in February, from Ballyhaise, Co. Cavan, by Mr. G. O. Sherrard. These galls are modified buds of the Common Spruce (*Picea excelsa*), and resemble small fir-cones in appearance. They contain numerous small chambers in which the insects live. The life-cycles of the European species of Chermes have been closely studied in recent years by Cholodkovsky (8), whose results are summarized for English readers in a clear and useful article by Burdon (4); the latter author adds some valuable original observations on the forms found by him in the neighbourhood of Cambridge.

Chermes forms a somewhat aberrant genus of the Aphidæ, allied to the notorious Phylloxera of the vine. The cornicles, so conspicuous on the abdomen in most aphids, are absent. The head is depressed and sometimes fused with the prothorax; the piercing jaws are very elongate in the wingless, shorter in the winged races; the feelers and legs are comparatively short. The gall received in February was dry and its chambers open, the young Chermes reared in it having left in the preceding summer. None of the insects themselves were observed, so that it is not possible yet to be sure which species of the genus may inhabit Ireland.

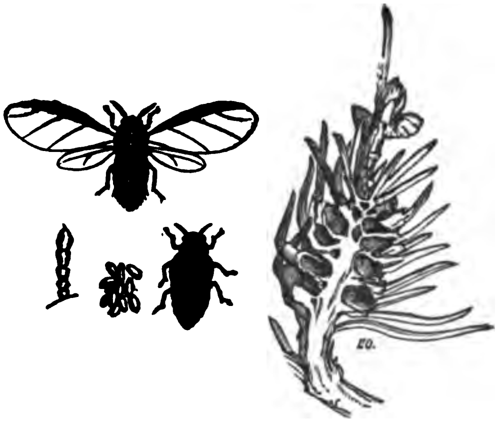

FIG. 10.—Spruce Aphid, *Chermes abietis*. Winged and wingless females with eggs, magnified; feeler, highly magnified; galls, natural size.

According to Cholodkovsky, some species or races of Chermes are entirely confined to the spruce and have no sexual generation, reproducing always parthenogenetically. Others migrate periodically between the spruce and the larch and have a sexual generation on the spruce whose members are the offspring of migrants from the larch. The species which Cholodkovsky identifies as *Chermes abietis*, Kalt., is stated by him to be nonmigratory. From eggs laid in August are hatched young, which hibernate on the buds of the spruce attached by their long beaks. In spring they begin to suck, and become in three or four weeks mature, wingless, parthenogenetic females, which lay their eggs and die. The attacked bud swells and forms a chambered gall within which the young of the next generation live and feed. Before their last moult they come out of their chambers, and develop on the needles into winged adults. These lay eggs whence develop the wintering young, so that there are two alternating parthenogenetic races—one wingless and the other winged.

A closely allied species, *C. viridis* Ratz., formerly confounded with *C. abietis*, has migratory habits and a sexual generation. Here the winged females migrate to larch to lay their eggs ; and on that tree the young pass the winter in crevices of the bark. They become adult in spring, and though they form no galls, their presence on the tree and the perforations that they make allow entrance to the spores of the canker fungus. From their eggs are hatched a summer brood of winged parthenogenetic females which migrate back to the spruce in early summer and lay eggs thereon. From these eggs are developed the small sexual insects —wingless males and females—from whose fertilized eggs arise the wingless parthenogenetic race destined to produce galls in the ensuing spring.

The winged virgin females are, in both species, the largest race, measuring 2–2·5 mm. in length, the wingless gall-makers being about ·7 mm., and the sexual forms of *C. viridis* only ·5 mm. According to Cholodkovsky the virgin wingless females and their eggs are yellow in *C. abietis*, and green in *C. viridis*, and there are minute structural differences between the two forms corresponding with the differences in life-cycle noted above. Burdon found, however, that the specimens of Chermes examined by him at Cambridge did not conform strictly to these distinctions, so that he felt doubtful as to which species they should be referred to. The question presents, therefore, much opportunity for further research.

The Tasmanian Storehouse Beetle.

Ptinus tectus, Boield.

(Plate LIV.)

In November our Registrar, Mr. R. J. Moss, handed me a tin of almonds from his house at Killiney, in which were feeding a number of small rotund beetles covered with a fine golden pubescence. The species being unknown to me, I consulted my friend, Mr. J. N. Halbert, of the National Museum, who kindly identified the beetle as *Ptinus tectus*, Boieldieu. It was first recorded from the British Islands three years ago by Hudson Beare (2), having been found several years before that in a granary at Stroud, Kent, and in a London shop. Later in 1905 it was noticed at Liverpool and elsewhere in the north of England; and in 1906 Hudson Beare (3) announced two Scottish localities—a flour-mill at Dunfermline and a bake-house at Stromness in the Orkneys. All the localities so far noticed are seaports or places near ports, and the beetle must doubtless be regarded as a recent importation from abroad, though it may possibly become well established in our islands in course of time. According to Mr. C. O. Waterhouse, its probable home is Tasmania.

The genus (Ptinus), to which it belongs, is world-wide in distribution, and we have several species that feed in timber, of which the well-known *Ptinus fur* is the most common. Probably a large proportion of the household store-house insects, which are now regarded as regular members of our fauna, were introduced by commerce into this country before the species of small insects had been carefully studied and distinguished.

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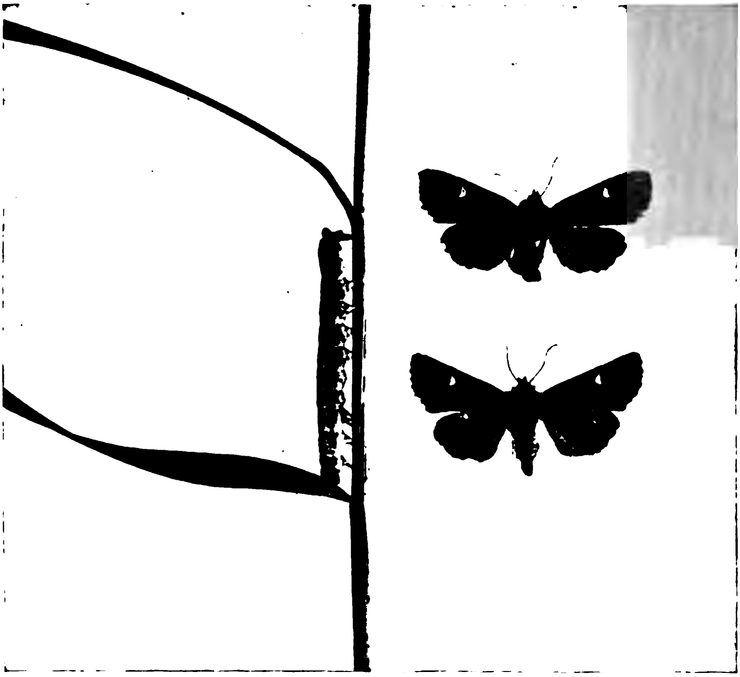
EXPLANATION OF PLATE XLIX.

PLATE XLIX.

A—Common Rustic Moth (*Apamea didyma*). Two varieties of the moth with caterpillar on grass. Photograph by T. Price.



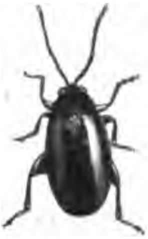
A

EXPLANATION OF PLATE L.

PLATE L.

B—"Turnip-flies." 1. *Phyllotreta nemorum.* 2. *P. consobrina.* Magnified. Photograph by T. Price.

C—Mangold-eating Ground-beetles. 1. *Pterostichus cupreus.* 2. *Taphria nivalis.* Magnified. Photograph by T. Price.



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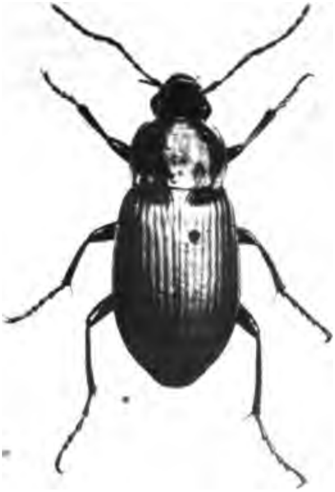

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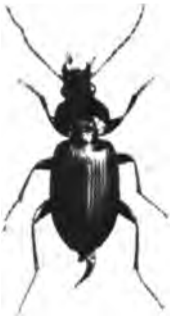

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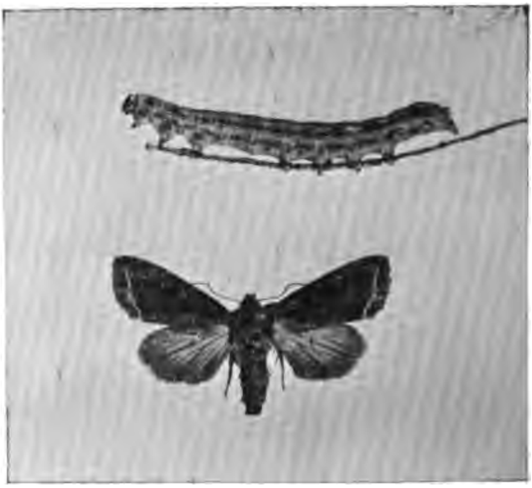
C

EXPLANATION OF PLATE LI.

PLATE LI.

D—Brocade-Moth (*Mamestra oleracea*) and its **caterpillar.**
Photograph by T. Price.

E—Cabbage-Moth (*Mamestra brassicæ*) and its **caterpillar.**
Photograph by T. Price.



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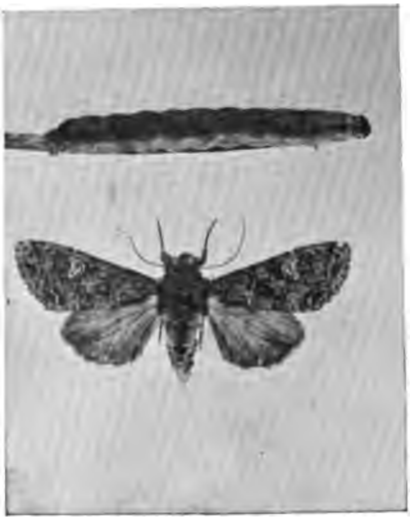
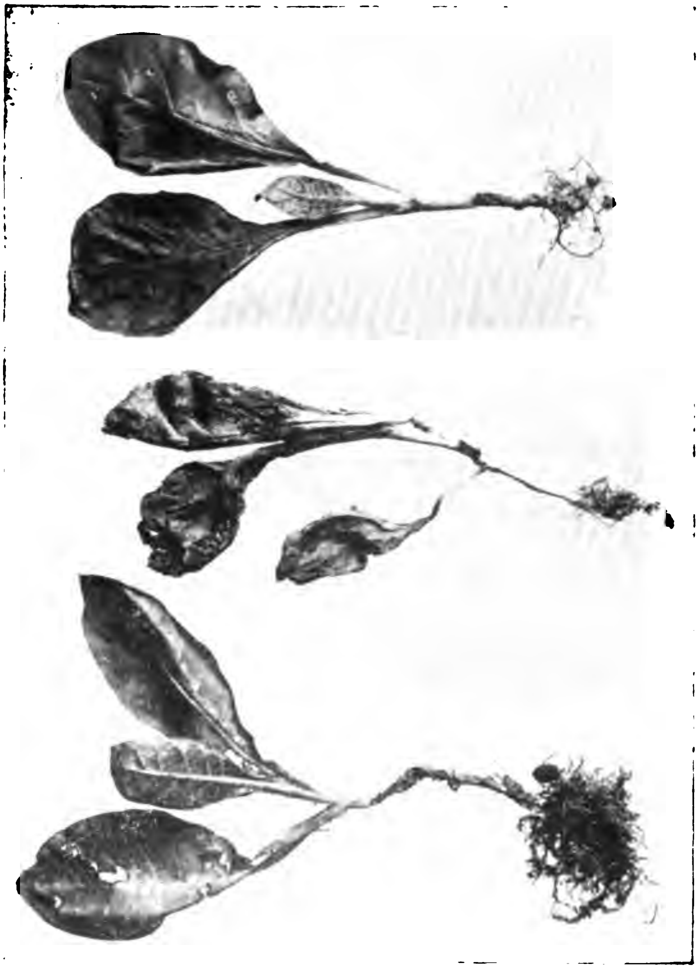


E

EXPLANATION OF PLATE LII.

PLATE LII.

F—Tobacco **Seedlings eaten by** Wireworms. **Photograph by T. Price.**



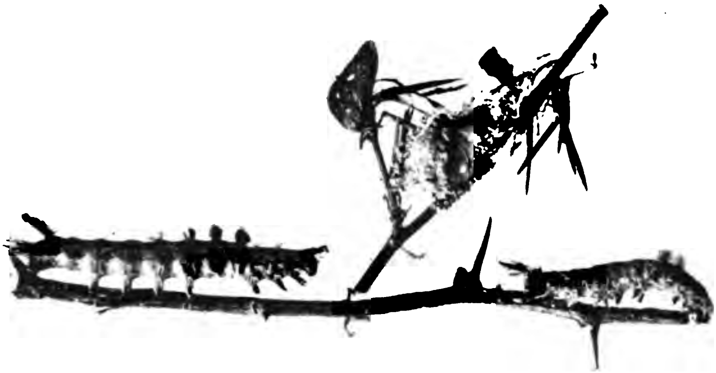
F

EXPLANATION OF PLATE LIII.

PLATE LIII.

G—Vapourer Moth (*Orgyia antiqua*). Male, Female, Cocoon, Eggs, and Caterpillars. Photograph by I. Swain.

H—Sawfly (*Nematus maculiger*) and its cocoon. Magnified. Photograph by T. Price.



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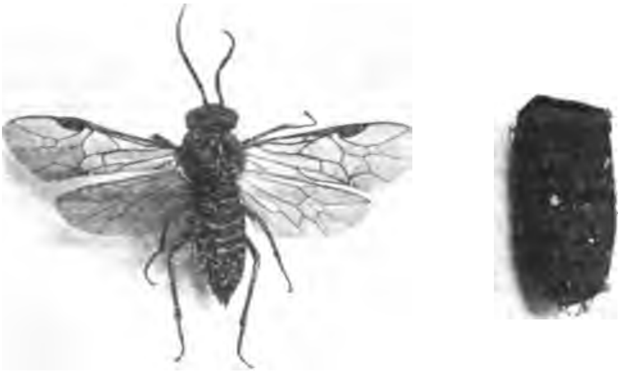
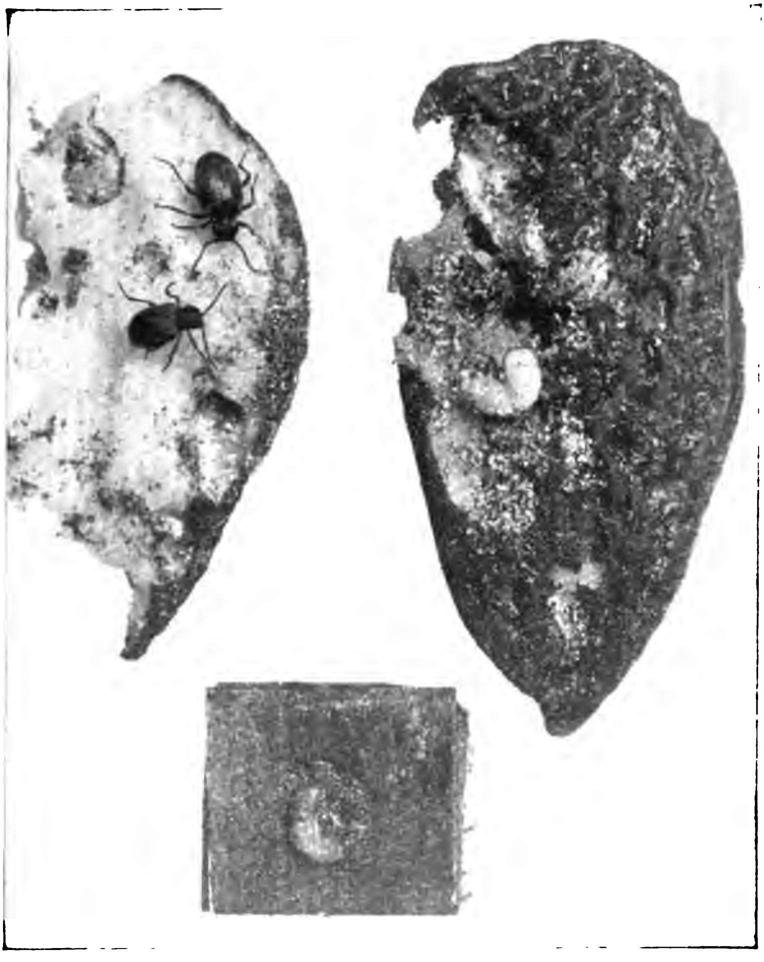


H

EXPLANATION OF PLATE LIV.

PLATE LIV.

J—Beetles (*Ptinus tectus*) with larvæ on Almonds. Magnifi
Photograph by T. Price.



J

XXIV.

INJURIOUS INSECTS AND OTHER ANIMALS OBSERVED IN IRELAND DURING THE YEAR 1908. By GEORGE H. CARPENTER, B.SC., M.R.I.A., F.E.S., Professor of Zoology in the Royal College of Science for Ireland, and Consulting Entomologist to the Royal Dublin Society.

(Plates LV.-LIX.)

[Read, May 25; Received for Publication, June 2; Published, July 30, 1909.]

CORN AND GRASS INSECTS.

Crane-flies.

Tipula oleracea (Linn.) and other species.

The destructive grubs of these common insects have been frequently mentioned in this series of papers (4, pp. 197-9, 249, 281-2, 291). At the end of May, 1908, they were reported by Mr. J. Johnston, Agricultural Instructor, in County Waterford, as exceptionally injurious to growing oats in his district. Some fields that he observed were eaten quite bare, hardly a plant being left except for a space of 10 or 15 yards from the fences, within which the grubs had done but little damage.

In County Cavan, late in August, the flies were abnormally abundant, "like a swarm of locusts," according to the observations of Mr. J. A. Faris, of Cornafean.

The Silky Beetle.

Dascillus cervinus (Linn.).

(Plate LV.)

Early in February, 1908, I received for identification from the editors both of the *Farmer's Gazette* and the *Irish Farming World* a number of unfamiliar beetle-larvæ that were believed to be injuring the roots of young oat-plants and of grasses in pastures. Mr. W. J. Walsh, of Kingswood, Clondalkin, County Dublin, who had sent one batch of specimens, was good enough to forward subsequently a number of living grubs, one of which pupated on April 10th; and the perfect beetle, which proved to be *Dascillus cervinus*, appeared on April 29th.

Meanwhile a specimen of the same larva, also from County Dublin, had reached the British Museum, where Mr. C. O. Waterhouse identified it from an old description by Erichson as belonging to *Dascillus cervinus*. An account of its structure was subsequently published by Mr. C. J. Gahan (6), who, in correspondence with me on the subject, pointed out the observations recorded a few years ago by Boas (1). In one of the last-named zoologist's papers there is a good figure of the larva, and in the other of the pupa; but his work, on account of the medium of its publication, has escaped the notice of most English-speaking zoologists.

The cuticle of the larva (Plate LV., fig. 1) is firm and well-chitinised. The head is very large, with a broad, curiously asymmetrical labrum (fig. 1 a) and rather elongate four-segmented feelers, the terminal segment being minute (Plate LV., fig. 2). Each mandible (Plate LV., fig. 3) has at the tip a sharp tooth and two cutting teeth on the inner face, beneath which is a slender hinged tooth (*prostheca*), that of the left mandible longer and more slender than that of the right, and a broad basal molar or grinding surface. The maxilla (Plate LV., fig. 4) is remarkably like the maxilla of a developed beetle, consisting of cardo, stipes, lacinia with bifid tip, pointed galea, and three-segmented palp. The labium (fig. 5) has a broad mentum, an emarginate ligula, and a pair of two-segmented palps; the ventral sclerite, to which the mentum is jointed, lies very distinctly posterior to the general head-skeleton, recalling the primitive arrangement that characterizes the Orthoptera.

The thoracic segments are short and broad, the legs being rather elongate, each consisting of a coxa, trochanter, femur, tibio-tarsus, and single slender claw (Plate LV., fig. 1). The abdomen tapers slightly to the hinder end; nine tergites are visible dorsally, as is usual in beetle larvæ; the ninth is evenly rounded behind, and bears a pair of short acute processes.

According to Boas' observations (1) in Denmark, the grubs live in bog-meadows where they eat the roots of grass, so that hay and pastures suffer severely, the highest and dryest parts of the meadows being most attacked; they also injure oats. In the case of the specimens that I kept for some weeks alive under observation, I noticed that they hung on to grass roots with their large mandibles, while the crops of specimens that I dissected contained particles of earth and fragments of plant tissues. Gahan observes that "the large basal molar tooth with which each of the mandibles is furnished affords strong evidence as to the vegetable-feeding habits of the larva."

The life-cycle occupies two years according to Boas' statement, from which it appears that pupation takes place about the same time of year in Denmark as in Ireland. Some of the specimens from County Dublin were only half as large as the full-grown ones; presumably they were in their first year of larval life. The pupa (Plate LV., fig. 6) is of the usual "free" coleopterous type, lying on its side in an earthen chamber with the body bent almost into a semicircle. Spiracles are present on the abdominal segments from the second to the seventh, inclusive, and the ninth abdominal segment is prolonged behind into a pair of sharp processes. The tenth (anal) segment does not extend beyond the ninth.

The Dascillidæ are a family of beetles represented in our fauna by a few terrestrial, marsh-haunting, and aquatic species. *Dascillus cervinus*, the only Irish species of its genus, is often found under stones, especially in hilly districts. It is an elongate beetle (Plate LV., fig. 7), with rounded prothorax, and small head carrying feelers, with eleven segments, inserted directly in front of the eyes; the shins of the legs are slender, and each foot has five segments. The insect is fawn-colour, with darker markings on the prothorax, and the whole body is covered with a dense pale silky pubescence.

Dascillus cervinus is widely distributed in Ireland, occurring most frequently in the hill districts. Besides the County Dublin localities, County Wicklow also proved to be a centre for the insects in 1908. More than twelve years ago I received a number of the grubs from Westmeath, where they were injuring an oat crop; at that time I failed to rear or identify them.

The preventive and remedial measures usually taken against wire-worm and crane-fly grubs might be tried with hope of success against the larvæ of Dascillus. Boas states that kainit has certainly a harmful effect on the insects.

CABBAGE AND TURNIP INSECTS.

The Cabbage Aphid.

Aphis brassicæ, Linn.

The familiar "green-fly" of the cabbage has been already described at some length in this series of papers (4, pp. 321–6). It was reported in August, 1908, as extremely troublesome at Killorglin, County Kerry, and at Loughrea, County Galway.

The Brassy "Turnip-fly."

Phyllotreta consobrina, Curtis.

An account of this insect was given in the last of this series of papers (4, pp. 569–70). Specimens were received in July from Celbridge, County Kildare, where they destroyed six beds of Brussels-sprouts and two beds of cabbage, not leaving a single plant. Plenty of lime and soot was scattered over the plants without the least effect.

The Cabbage-fly.

Phorbia brassicæ, Bouché.

Every year brings complaints of the ravages of this common maggot (4, pp. 141–4). In June, 1908, specimens were received from near Dublin and from Naas; at the latter locality roots were eaten right across, and the crop, over an acre, badly damaged. In September the maggots were found near Dundalk in the crowns of Swedes, so that the crop was seriously injured.

The Turnip Moth.

Agrotis segetum, Schiff.

Fully grown specimens of the caterpillars of this common moth (see 4, pp. 432–4) were sent at the end of August from the neighbourhood of Cork, by Mr. J. Adams, Agricultural Inspector for the county. They had done much damage to a field of Swedes by their usual habit of feeding inside the roots.

The Cabbage Butterflies.

Pieris brassicæ (Linn.), *P. rapæ* (Linn.), and *P. napi* (Linn.).

During the summer and autumn of 1908 complaints were received from the western counties (especially Galway, Mayo, and Donegal) of exceptional damage by the caterpillars of these familiar insects, the warm weather having apparently favoured their excessive multiplication.

POTATO PESTS.

The Field Slug.

Agriolimax agrestis (Linn.).

(Plate LVI.)

In a previous paper (4, pp. 326–8), this common and destructive mollusc was figured and described. In February, 1908, specimens of potatoes bored and tunnelled by the slugs (see Plate LVI.) were received from Mr. A. Carrick, County Agricultural Instructor, Monaghan. The potato crop was damaged in this way in several localities in the county, but it is noteworthy that tubers of the "Up-to-date" variety entirely escaped injury.

Spotted Snake-Millipedes.

Blaniulus sp.

Attention has been previously directed (4, pp. 295, 434, 441) to the great damage which these small millipedes frequently do to potato-tubers. Similar cases of injury were reported from County Dublin in February, and from near Cork in October. The application of a dressing of salt, and the "planting" of hollowed-out mangels as traps, seem the remedies most readily available.

MANGEL INSECTS.

The Black Aphid.

Aphis rumicis, Linn.

These "collier" aphids are very familiar to all gardeners from their habit of crowding high up on the shoots of bean-plants. In August specimens were received from Limerick, which had similarly attacked mangel. In 1895 a severe attack on the mangel crop by this species was recorded in North Wales (Omerod, 10, pp. 51–6). It is very variable in the nature of its food-plant. The black wingless females (fig. 1, 4) that crowd on the plants through the summer, and bring forth active young by virgin reproduction, are the most familiar form of this insect.

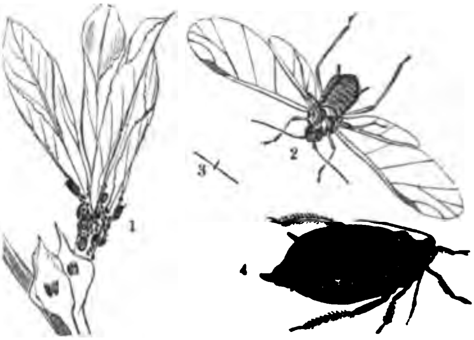


Fig. 1.—Black Aphid or "Collier" (*Aphis rumicis*). 1. Aphids on Bean-shoot, natural size. 2. Male, magnified. (3 shows natural size.) 4. Wingless virgin female, magnified. From Ormerod's "Reports."

The winged virgin females which migrate and spread infection to other plants are also black, occasionally slightly rusty-brown. The nymphs from which the winged insects develop are slaty-grey with black wing-rudiments and a black hind-body which has white downy spots on each side arranged in series. In autumn black winged males (fig. 1, 2) and wingless egg-laying females are produced; the eggs which are laid after pairing remain unhatched through the winter, and give rise to virgin "stem-mothers" in the succeeding spring (see Buckton, 2, vol. ii., pp. 81–6).

On account of the conspicuous appearance of the colonies of these aphids, it is comparatively easy to cut off and destroy the infested leaves or shoots in cases where the area under the crop is not too great. As a spray-fluid, quassia-wash will probably be found effectual; and the exposed position of the aphids while feeding increases the chance of effective spraying to destroy them.

The Bright-line Brocade Moth.

Mamestra oleracea (Linn.).

In the last paper of this series (4, pp. 571–2) a description and figures were given of this moth and its caterpillar, which had proved destructive to mangel in the southern counties of Ireland. At the end of September, 1908, I received from Mr. J. A. Faris, of Cavan, further specimens of the caterpillars, with the information that in his neighbourhood the mangel crop had been badly injured by them, and that they had not previously been noticed in the locality. Evidently this insect is likely to prove itself worthy of attention by farmers.

ORCHARD INSECTS AND MITES.

The Black Currant and Hazel Gall-Mites.

Eriophyes ribis, Nal. and *E. avellanæ,* Nal.

The mite that causes "big bud" on Black Currant has been previously described and discussed (4, pp. 260–2, 301–2, 441, 581). In February, 1908, shoots infested with it were received from Ballymena, County Antrim. In March, Mr. Peter Brock, County Horticultural Inspector for Fermanagh, sent a Hazel-shoot with "big buds" very similar to those on the currant, and caused by an allied species of Eriophyes (*E. avellanæ*). Fear has been expressed that currant bushes might be infected from hazel, but the two species are quite distinct.

The Apple Sucker.

Psylla mali (Schmidb).

During the spring of 1908, complaints were received from many parts of the country of the damage done by the larvæ and nymphs of this insect, which on account of their small size are frequently overlooked. Mr. Seabrook of Chelmsford, who travelled through many counties of Ireland during the year, stated that in every orchard that he entered, whether in the north or in the south, traces of the ravages of the insect could be noticed. Specimens were forwarded to me from counties Dublin and Fermanagh.

The Psyllidæ or "Jumpers"—the family to which the insect belongs—are included in the Homoptera, that sub-order of sucking insects which comprises cicads, frog-hoppers, plant-lice or "green-fly," and scale-insects. The Psyllidæ have feelers with eight or ten segments, and feet with two segments only; the adults have large compound eyes, and also three ocelli or simple eyes. Usually both pairs of wings are transparent, and this is the case in *Psylla mali*, which is yellow or brownish in colour, with the two terminal segments of the feeler black.

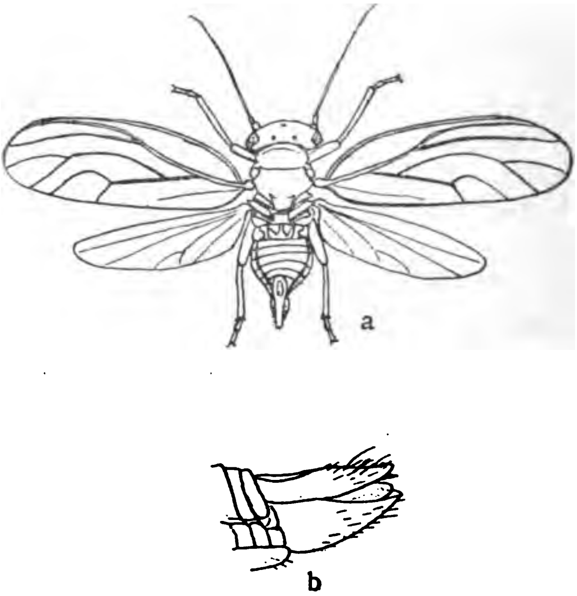


FIG. 2—(*a*) Apple Sucker (*Psylla mali*) female. Magnified 10 times.
(*b*) Ovipositor of female (lateral view). Magnified 40 times.

The adult winged insects may be seen flying and jumping about the trees in autumn. According to the statement of Theobald

(11, pp. 153–165)—who has lately given much attention to *Psylla mali* in the south of England—the eggs are laid in September, October, and early November. The egg is ·4 mm. in length and oval in shape, with a short "stalk" at one end by means of which it is attached to the apple tree (fig. 3, *a*). It is orange-red in colour, so that a number of eggs are conspicuous on the bark, especially when the branches are covered with green algal growth. The eggs are found mostly on the shoots, below the buds or around the leaf-scar ridges. They remain through the winter, and the young larvæ are hatched usually during the month of April. Shoots sent from Enniskillen by Mr. Peter Brock, on April 15th, had a number of unhatched eggs and a good many active first-stage larvæ on them.

The larval Psylla (fig. 3, *c*, *d*) differs in many respects from the adult. It is flat in form, the head and prothorax partly fused together; the feeler (fig. 3, *c*) has only six segments, while in the leg there is no differentiation between shin and foot (fig. 3, *e*). Between the two foot-claws there is a delicate adhesive pad. The larva of the Apple Sucker is dirty yellow, with bright red eyes, and secretes a white, woolly substance. The larvæ make their way to the buds, outside which they may sometimes be seen waiting for the leaves to open. As soon as possible they get inside the buds and suck sap from the young blossoms, which shrivel and become brown as if frost-bitten. After a time the larva becomes a nymph (fig. 3, *g*) with distinct rudiments of wings. The feelers are now more elongate (fig. 3, *g*, *h*); there are indications of segmentation in the foot (fig. 3, *j*), and the anal region differs in shape from the corresponding area in the larva (compare fig. 3, *f* and *k*).

The winged adults are developed as early as May, and they are still to be found in November; but the damage to the trees is done by the insect in the larval and nymphal stages.

With regard to preventive and remedial measures, it may be stated first, that no wash can be used with any prospect of killing the eggs. Theobald writes strongly on the point, and I may place on record that batches of twigs sent by Mr. Brock from four orchards in county Fermanagh, which had been sprayed in March with a wash advertised as effective, harboured numerous live eggs

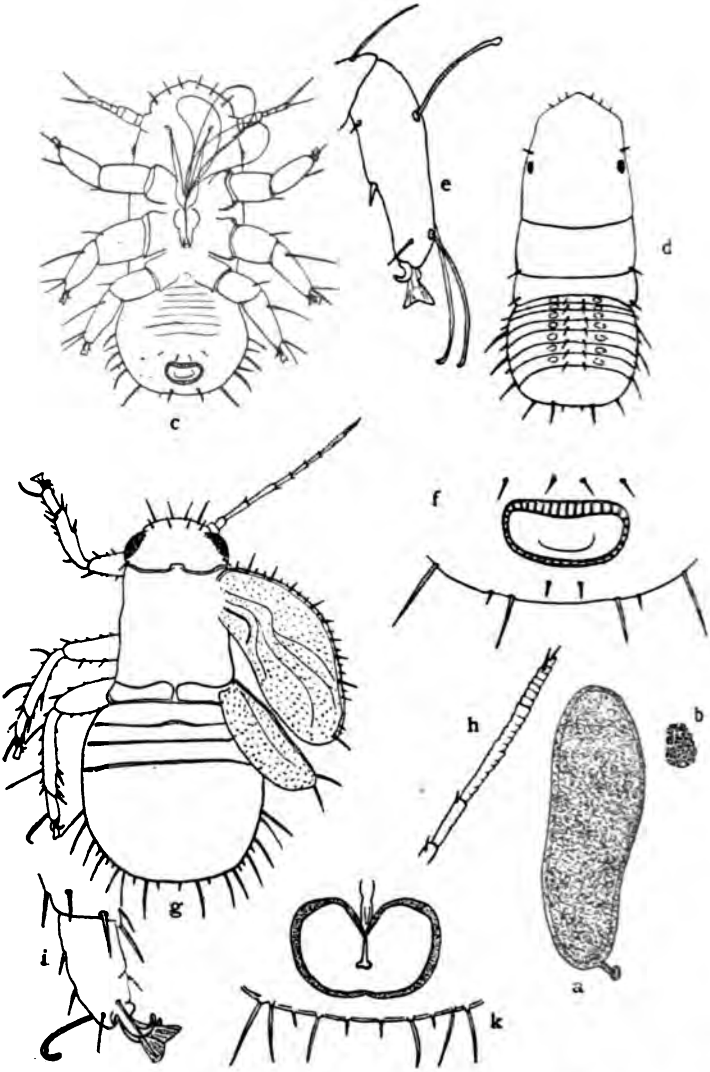


Fig. 3.—Young stages of Apple-Sucker (*Psylla mali*). (*a*) egg, × 90; (*b*) surface of egg-case, highly magnified; (*c*) young larva, ventral view, × 90; (*d*) young larva (appendages removed), dorsal view, × 90; (*e*) larval shin, foot, and claw, × 200; (*f*) anal area of larva, × 350; (*g*) nymph, × 25; (*h*) feeler of nymph, terminal segments, × 72; (*i*) foot of nymph, × 96; (*k*) anal region of nymph, × 60.

and newly hatched larvæ of Psylla. On the other hand, some twigs from an orchard at Newtownbutler, where this wash had not been used, were quite free from the suckers in any stage. With regard to these Mr. Brock informed me that they had been sprayed in the spring of 1907 with a mixture of sulphate of iron, caustic soda, and paraffin; evidently this wash had killed the newly hatched larvæ. In November, 1908, Mr. Brock again kindly sent me samples of apple twigs. Those that had been winter-sprayed in 1907–8, with the vain hope of killing the eggs, were covered with the eggs of the next generation; while those that had been sprayed twice in the spring of 1908 with quassia emulsion were free from eggs, the young suckers having been killed by this application. According to Theobald, nicotine-wash is more certain in its killing effects than quassia.

The vulnerable period of the sucker's life-history is, therefore, when the larvæ have emerged from the eggs. Theobald lays stress on the possibility of preventing their access to the buds, or indeed of preventing their exit from the egg by a thick application of salt and lime-wash in February; he states that such a wash has a directly beneficial effect on the trees. The following is his formula for its composition:—

"Slake 1½ cwt. of the best white lime, fresh from the kiln, in a small quantity of water; then mix it into 100 gallons of water, strain off, so as to exclude all grits, into another receptacle, and add to the thick lime-wash 30 lb. of dissolved salt. This wash is improved by adding 3 to 5 lb. of water-glass, previously dissolved in warm water, as it tends to hold the wash longer on the trees."

The Mussel Scale-insect.

Mytilaspis pomorum, Bouché.

From Mr. Brock, of Enniskillen, were received also in March and in May shoots of apple trees infested with numerous scales of this familiar insect, which has already been described and figured (4, pp. 438–440). The shoots had been heavily sprayed in March with Cooper's V 1 fluid; about half the eggs were alive and half dead.

The Black Vine-weevil.

Otiorrhynchus picipes (Fab.).

Specimens of this beetle—described and figured in the last of these papers (4, pp. 579–581)—were received early in May from County Carlow, where they had done much damage by eating the leaves and bark on the stems of young apple and plum trees.

The Gooseberry Sawfly.

Nematus ribesii (Scop.).

Caterpillars of this well-known fly (4, pp. 335–7) were received in June from Counties Dublin and Antrim. In the Dublin district they attacked both gooseberries and currants.

The Raspberry Shoot Moth.

Lampronia rubiella, Bjerk.

The caterpillar of this moth is well known to fruit-growers in the south of England; but not until last year did I receive complaints of damage done by it in Ireland. In the middle of April, 1908, Mr. P. Brock, of Enniskillen, sent me shoots of raspberry canes, with the information that in the small plantation whence they came 75 per cent. of the buds had been destroyed. In July, shoots similarly injured were received from Mr. W. Cooper Clibborn, of Moate, County Westmeath.

The life-history of this insect was worked out some years ago by Chapman (5), and a good general account of its habits may be found in Theobald's recent book (11, pp. 416–419). The genus Lampronia belongs to the family Tineidæ, of which the "clothes-moths" are the most familiar members. *L. rubiella* is a beautiful little insect, measuring about 10 mm. (⅖ in.) across its outspread wings, which are of a purplish-brown colour with bright yellow spots, two large ones near the hinder edge of the wing being especially conspicuous. The moths are on the wing about midsummer, and lay their eggs on the blossoms of the raspberry canes. The young caterpillar burrows into the white receptacle in the centre of each fruit-bead, and remains there without feeding for some weeks, doing no harm to the fruit. Later it makes its way to cracks in the stalks, or beneath the bark of the canes, or on to the ground, and spins a small white silken cocoon in which it passes the winter. At the beginning of March it comes out of this hiding-place, ascends the raspberry canes, and eats its way into a shoot at the base of a bud. Here the caterpillars feed on the pith, and, as result of their presence, the buds either wither up altogether, or develop into shoots which surely fail sooner or later.

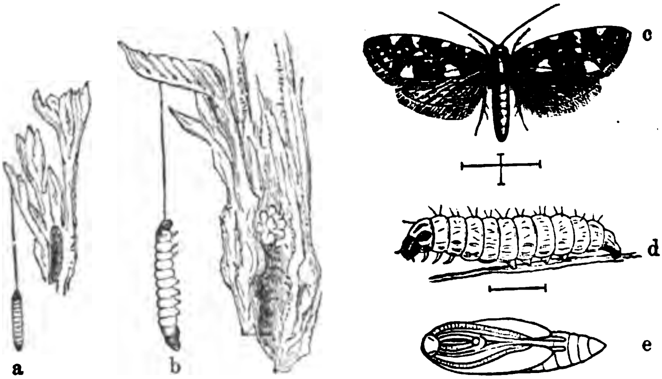


FIG. 4.—Raspberry shoot-moth (*Lampronia rubiella*): (*a*) caterpillar dropping from shoot, natural size; (*b*) the same magnified; (*c*) moth; (*d*) caterpillar; (*e*) pupa, magnified 3 times. From Ormerod's "Reports."

While the caterpillars are feeding in the canes in springtime, nothing can be done except to cut off and burn the attacked shoots. The vulnerable period of the insect's life-history is that of the wintering larvæ. These can be destroyed by burning the stakes, deeply forking the soil, and raking away the surface from the stocks, afterwards earthing them up again.

The Vapourer Moth.

Orgyia antiqua (Linn.).

An account with figures of this insect was given last year (4, pp. 577–8). An apple-shoot with a batch of its eggs was received from Antrim in February, 1908.

The Eyed Hawk-moth.

Smerinthus ocellatus (Linn.).

This large moth was also described and figured last year (4, pp. 578–9). Caterpillars were received in August from Mr. James Harvey, of Clonakilty, County Cork, who stated that they were rather destructive in the neighbourhood.

GARDEN PESTS.

Slugs and Snails.

Agriolimax agrestis (Linn.) and *Helix rufescens*, Pennant.

(Plates LVII. and LVIII.)

The common Field Slug (*Agriolimax agrestis*) has been already mentioned in connexion with damage to Potatoes (p. 593). In the summer of 1908 complaint was received from Mr. R. M. Barrington, Fassaroe, Bray, that the leaves of wallflower seedlings were being eaten into holes (Plate LVII.), and that no depredator was visible. Investigations after dark with a lantern revealed the presence of numerous specimens of *Agriolimax* and of *Helix rufescens*, which, climbing up the plants every night, devoured the leaves greedily. The latter species (Plate LVIII.) is one of the commonest of our smaller snails. The shell is of a dull brown colour, flattened in form, with six or seven whorls, often bluntly keeled on the outer edge, and with a deep umbilicus.

A dressing of lime around the plants would be found the most effective means of checking such an attack.

Millipedes.

Blaniulus, *Iulus*, and *Brachydesmus*.

Complaints of damage done by various kinds of millipedes to garden plants were fairly common in 1908. In an old garden at Sandymount, County Dublin, Mr. A. E. Moran, of the Society's office, found in July the roots of cauliflower, broccoli, lettuce, and carnations eaten through by large numbers of the slender, whitish, red-spotted snake-millipedes (*Blaniulus*) that have been mentioned in former years (4, pp. 295, 434, 441).

Similar damage was done, also in July, in a garden at Manorhamilton, County Leitrim, where a small, black species of *Iulus* cut through flowering-plants below the soil. In this case it was stated that a dressing of soot and lime had no effect on the millipedes.

In June, Mr. Peter Brock, of Enniskillen, sent specimens of *Brachydesmus*—a genus of millipede, which, like *Polydesmus*, has flattened out-growths from the body segments. These millipedes had proved highly destructive to primroses extensively grown for sale, and some belonging to valuable varieties. Soot had no effect on the animals; and where vaporite was applied, the plants were attacked nearer the surface of the soil than in the case of the undressed ones, so that they suffered more severely. Mr. Brock recommended watering the plants with paraffin emulsion.

A New Bulb Mite.

Histiogaster corticalis (Michael).

In February I received from the Royal Botanic Gardens, Glasnevin, a bulb of Hippeastrum attacked by mites which were feeding just beneath the covering scale-leaves. Examination showed that the mites were of the species *Histiogaster corticalis*, described and figured by Michael (8, pp. 66–71, pl. xxviii.), and found by him in various parts of England in the common reed and other plants, "immediately beneath the epidermis, . . . eating their way along . . . leaving small furrows behind them filled with dust, excremented matter, &c." On the present occasion their action was similar.

These mites belong to the Tyroglyphidæ—the family of the cheese and hay mites, and of the root mites (Rhizoglyphus). The species of Histiogaster are elongate and narrow, with a marked constriction around the middle of the body in front of the third pair of legs. The first pair of appendages are stout and powerful pincers; the legs are short with some long flexible hairs and a few clubbed bristles, but few spines. The "hypopial" nymph stage —so characteristic of this family—has been described and figured by Michael; it is more evenly ovate in shape than the adult, and not markedly narrowed at the head region, as the mature mites, both male and female, are.

On account of the concealed manner of feeding adopted by these mites, nothing can be done except to destroy the bulb that they infest.

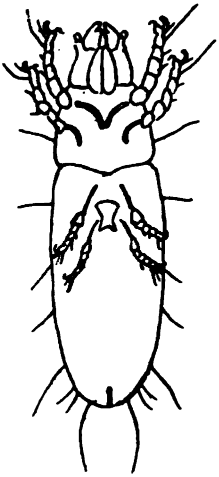


FIG. 5.—Bulb Mite (*Histiogaster corticalis*) Female, ventral view. Magnified 100 times.

The Lettuce Root Aphid.

Pemphigus lactucarius, Pass.

In September, 1908, lettuce plants were received from gardens at Banbridge, County Down, and Terenure, Dublin, with the roots badly infested by colonies of this aphid. The insects are covered with a white waxy secretion, which renders them very conspicuous when present in large numbers. They suck sap from the roots, and thus cause the plants to droop. The genus Pemphigus includes several species of aphids without cornicles, with simple wing-neuration, and with six-segmented feelers. According to Buckton (2, vol. iii., pp. 124-6), the young larvæ are narrow and worm-like in form. Colonies of this aphid are to be found at the roots of wall-flowers and other plants as well as of lettuce. Among the specimens examined were both winged and wingless virgin females (fig. 6, *a*) and immature individuals, some (fig. 6, *b*) elongate wingless larvæ, and a large number of nymphs (fig. 6, *c*), with conspicuous narrow wing-rudiments.

Plants badly attacked by these aphids should be removed and burned. For those less severely affected, the injection of carbolic acid emulsion into the soil might be advantageous.

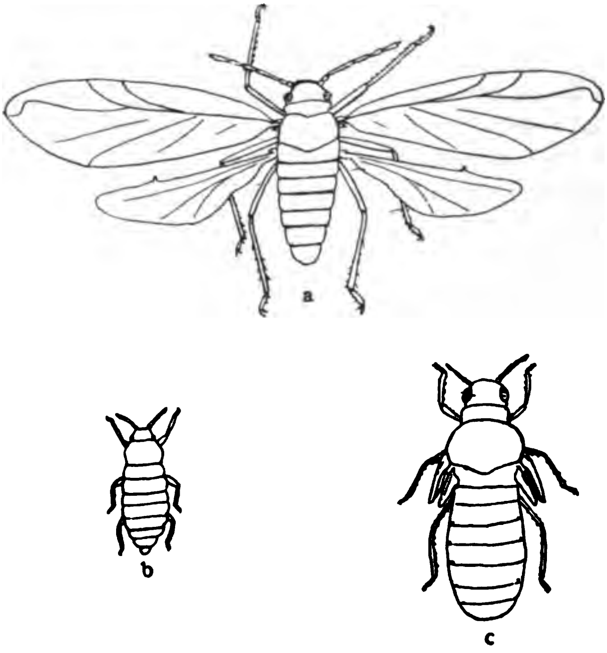


FIG. 6.—Lettuce Root-aphid (*Pemphigus lactucarius*).
(*a*) Winged female; (*b*) larva; (*c*) nymph. Magnified 16 times.

The Vine Scale-insect.

Lecanium persicæ (Geoffr.).

Shoots of grape-vine with numerous female scales of this insect were received in June, 1908, from Rathmines, Dublin. The scales, which are broad and saddle-shaped, have been well described and figured by Newstead (9, vol. ii., pp. 89-93, pl. li.).

The Black Weevil.

Otiorrhynchus sulcatus (Fab.).

The grubs of this common beetle were sent from the Royal Botanic Gardens in June, where they did much damage by eating the base of Cyclamen bulbs. The accompanying illustration (Plate LIX.) gives a good impression of the nature of the injury.

The Yellow Ant.

Lasius flavus (Fab.).

This is one of our commonest and best-known species of ant, and is not usually regarded as of any economic importance. In the year 1908, however, from midsummer until autumn, a garden near Waterford was infested with such enormous numbers of the insects that they became a serious pest. Mr. J. Johnston, the County Agricultural Instructor, kindly forwarded specimens of the ants for identification, and gave a vivid account of their abundance. He wrote:—" The place is simply alive with them; the lawn and garden, covering about four acres, is a huge ant heap. They are everywhere—under the walks, in the walls, and in the greenhouses."

Nothing but systematic excavations, and drenching the nests preferably with very hot water, would be of service against such an invasion, the mischief being too widespread for the use of carbon bisulphide injections, except at enormous expense.

FOREST INSECTS.

The Willow and Ash Scale-insect.

Chionaspis salicis (Linn.).

In March, 1908, Mr. J. W. Warburton, of Rostrevor, sent a shoot of ash with the scales of this insect, which has already been described and figured in these papers (4, p. 263, pl. xxii., 2).

The Fir and Pine Aphids.

Chermes piceæ (Kalt.) and *C. corticalis* (Kalt.)

An account of some aphids of the genus Chermes was given in my paper of last year (4, pp. 584–6). At the end of May, branches of Scots pine, received from a Dublin garden, were covered with the white cottony secretion due to *Chermes corticalis.* According to Gillanders (7, p. 331) this species is common and injurious in the south of England. At the end of November shoots of silver fir from Delgany, County Wicklow, were received with deformed growth caused by a species of Chermes, which appeared to be the little-known species *C. piceæ*, Ratz. According to Burdon (3, p. 132) only the wingless colonial generation of this insect is known.

Willow Beetles.

Phyllodecta sp.

The small leaf-beetles that devour, both in the larval and perfect stages, the leaves of osiers and willows, have been described and figured in a previous paper (4, pp. 449–450). Attention was called by Mr. W. S. Irving to the damage done by these insects to willows about 8 feet high near Claremorris, County Mayo.

The Pine Beetles.

Hylurgus piniperda (Linn.).

This well-known and destructive insect has been already described and figured in this series (4, pp. 443–6). At the end of December I received tunnelled shoots from the Royal Botanic Gardens, where the insect had been remarkably troublesome; probably the wintering specimens in the shoots were invaders from some neighbouring neglected plantation. A comparison of different coniferous woods shows conclusively the value of clearing away old stumps and barking felled trees.

The Pine Sawfly.

Lophyrus pini (Linn.).

This common enemy of conifers has been previously described and figured (4, pp. 447–8). It occurred at the end of July, 1908, on *Pinus insignis* at Abbeyfeale, County Limerick.

The Laburnum Moth.

Cemiostoma laburnella, Staint.

In the autumn of 1908 the caterpillar of this moth attracted much attention in the suburbs of Dublin, in Belfast, and at Moneygall, King's County, whence specimens were forwarded to me by Mr. T. R. Garvey. The caterpillars feed in September in the leaves of the laburnum, mining between the two leaf-skins, and causing unsightly brown patches to appear. They spin fine silken threads, by means of which they let themselves down from the branches, and swing to and fro in the air. In such large numbers did they indulge in this exercise that they were frequently a considerable annoyance to the passers-by on suburban roads or country avenues where laburnums are extensively planted. They finally come down to the ground or to some support, spin white elongate silken cocoons, and within these pupate. In several cases they selected an inclined laburnum trunk as a suitable station, and the bark was whitened by their numerous cocoons. In this stage they pass the winter, and a spring brood of moths may be seen on the wing in April.

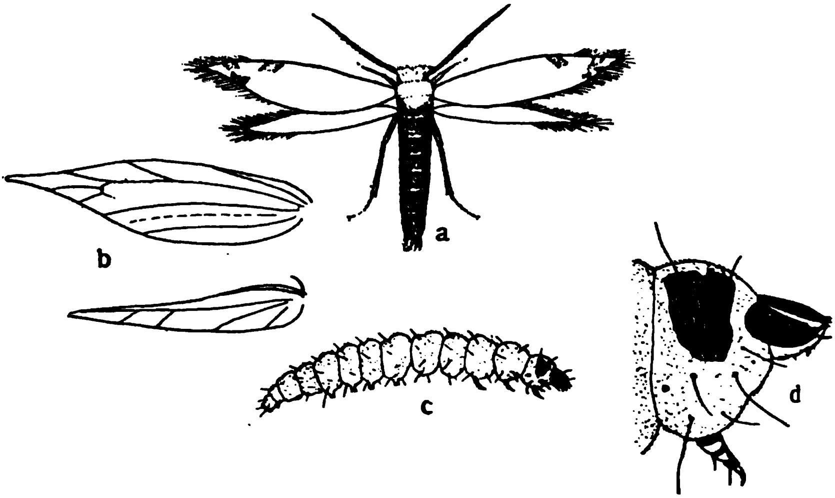


FIG. 7.—(*a*) Laburnum Moth (*Cemiostoma laburnella*), magnified 8 times; (*b*) Wing-neuration (after Meyrick) magnified 12 times; (*c*) Caterpillar, side view, magnified 8 times; (*d*) Head and prothorax of caterpillar, side view, magnified 38 times.

The moth is a beautiful little creature, measuring only 8 mm. (⅓ inch) across the outspread wings, which are for the most part pure white with an oblique yellow bar edged with dusky scaling from the costa, and a metallic spot edged with black on the inner edge of the forewing. The wing-fringes, as well as the head and face, are white. The moths lay their eggs below the leaves, usually near the midrib, and the caterpillars feed through June on the upper surface of the leaves, pupating in July beneath the leaves. The second brood of moths, which are the parents of the autumn caterpillars, are on the wing in August. According to Gillanders (7, pp. 287–9) the insect is much commoner on *Cytisus Laburnum* than on *C. alpinum*. The wintering cocoons can be destroyed by washing the trunks and forking the soil around the trees. If practicable, the blotched leaves with the feeding caterpillars should be removed and burned in September.

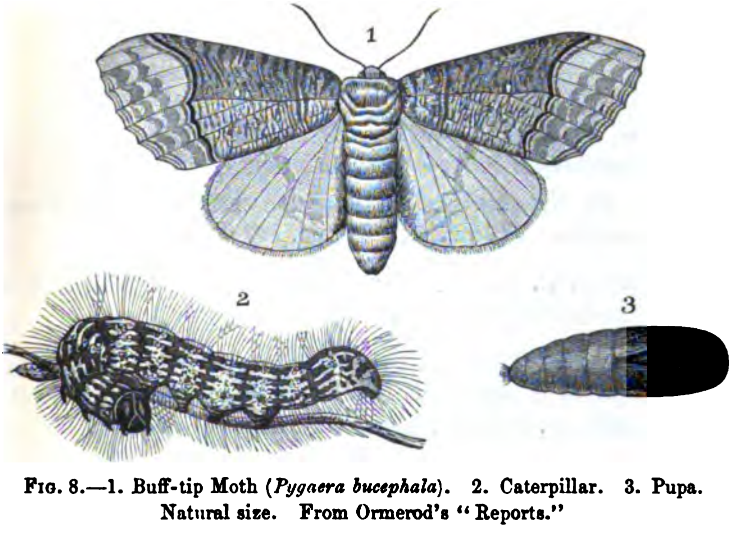


FIG. 8.—1. Buff-tip Moth (*Pygaera bucephala*). 2. Caterpillar. 3. Pupa. Natural size. From Ormerod's "Reports."

The Buff-tip Moth.

Pygæra bucephala (Linn.).

Caterpillars of this moth were received in September from Mr. H. Macardle, of Dundalk, with the information that they were proving destructive to lime trees by eating the leaves into holes. The moth is a well-known, handsome insect, measuring 50–60 mm. (2–2¼ inches) across the wings; the forewings are silvery grey with a conspicuous yellowish blotch at the tip. It appears in June and July. The eggs are laid in clusters below the leaves, and the young caterpillars, which are hatched in August, feed side by side in companies, eating one leaf after another, and migrating from branch to branch. When fully fed, in September, the caterpillar (43 mm. or 1¾ inch long) has a round black head with yellow lines, a yellowish green body with grey markings, and a broad black dorsal stripe, the whole clothed with fine whitish hairs. The pupa remains through the winter on the ground.

According to Gillanders (7, pp. 251–3) the caterpillars may be shaken down into sheets, for destruction, while the soil around the trunks may be limed in winter in order to kill the pupæ.

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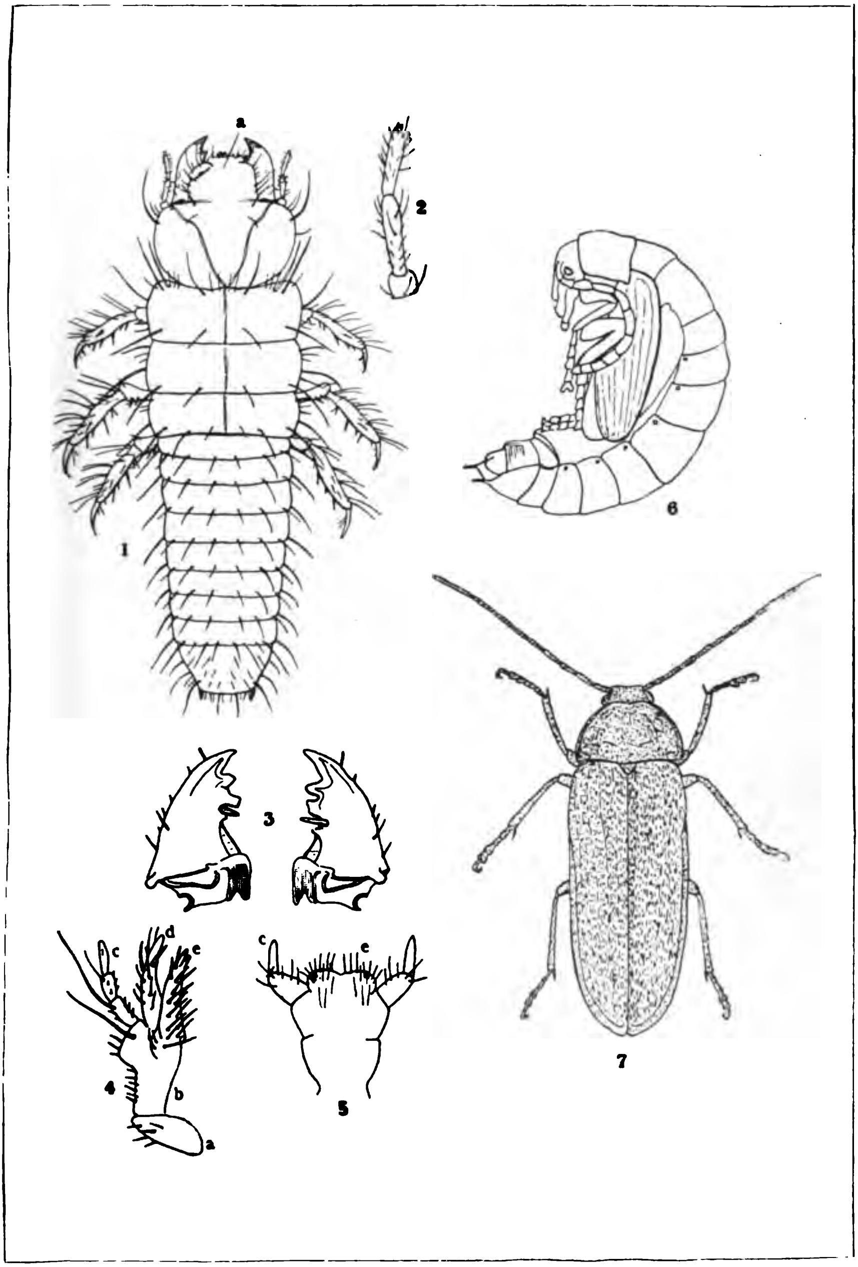


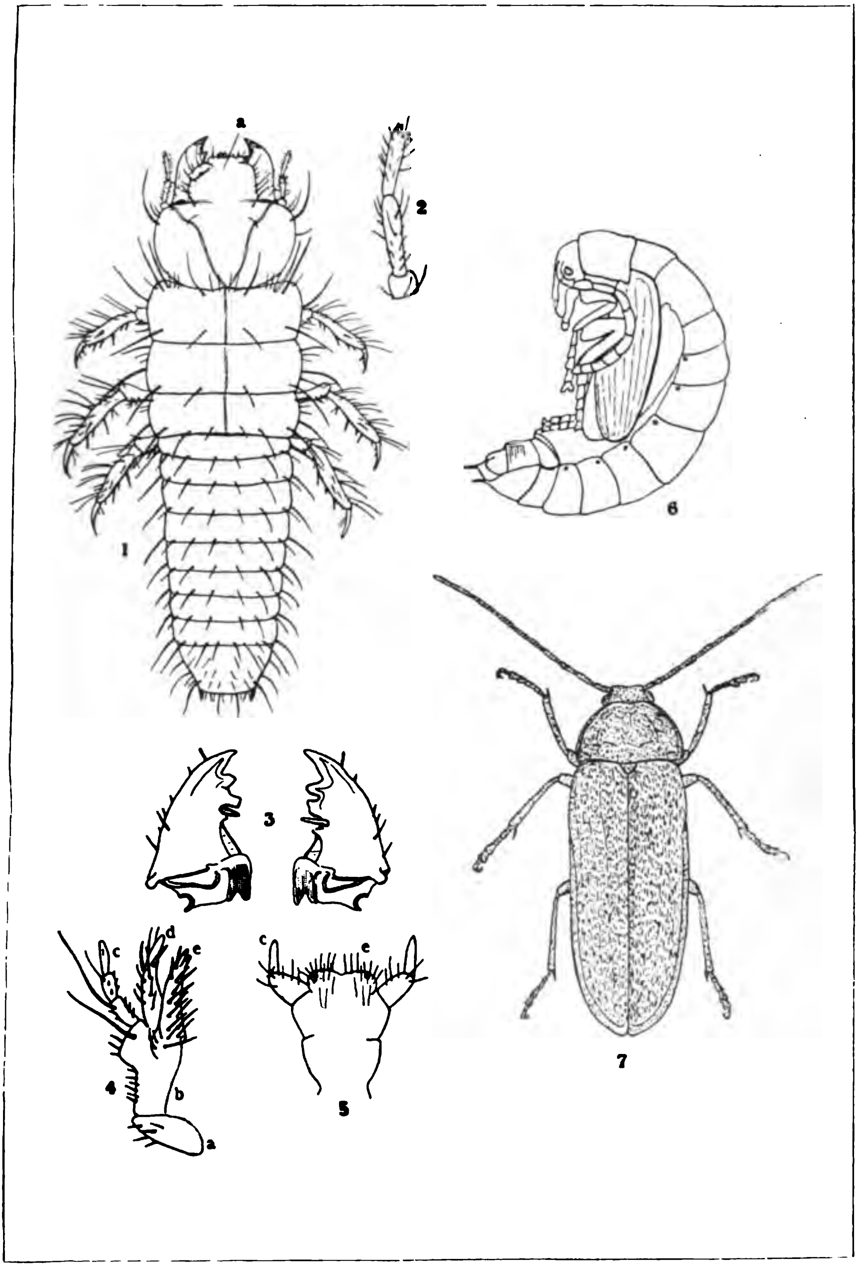
G. H. C., del.

PLATE LV.

Dascillus cervinus (Linn.).

FIG.

1. **Larva, dorsal view. Magnified 5 times. The legs have been pulled out from beneath the body). (*a*) labrum.**
2. **Right feeler of larva. Magnified 15 times.**
3. **Mandibles of larva (ventral view). Magnified 9 times.**
4. **Left maxilla of larva (ventral view). Magnified 15 times. (*a*) cardo ; (*b*) stipes ; (*c*) palp ; (*d*) galea ; (*e*) lacinia.**
5. **Labium of larva. Magnified 15 times. (*c*) palp ; (*e*) ligula.**
6. **Pupa, lateral view. Magnified 5 times.**
7. **Beetle, dorsal view. Magnified 5 times.**



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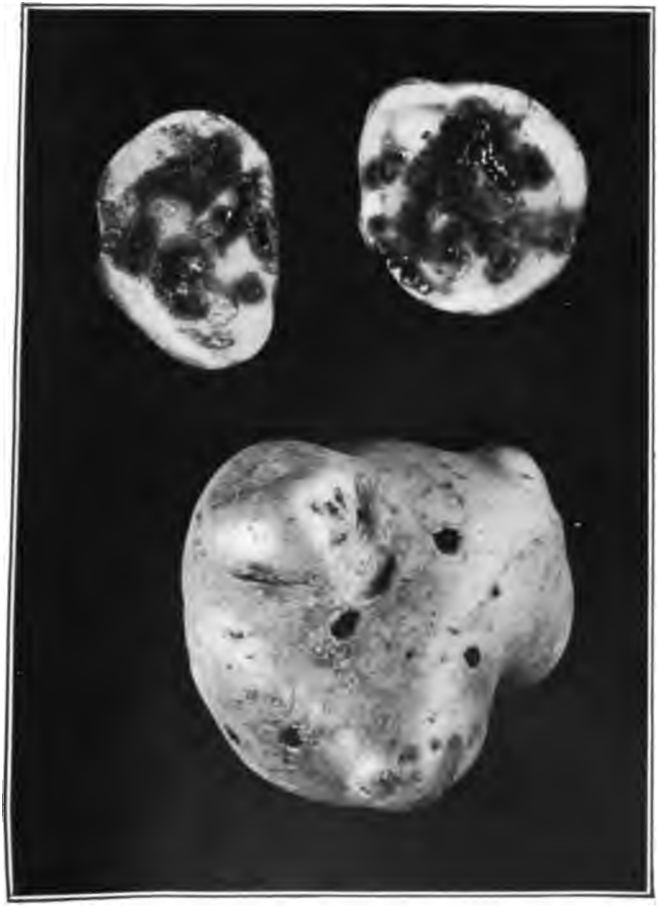
EXPLANATION OF PLATE LVI.

PLATE LVI.

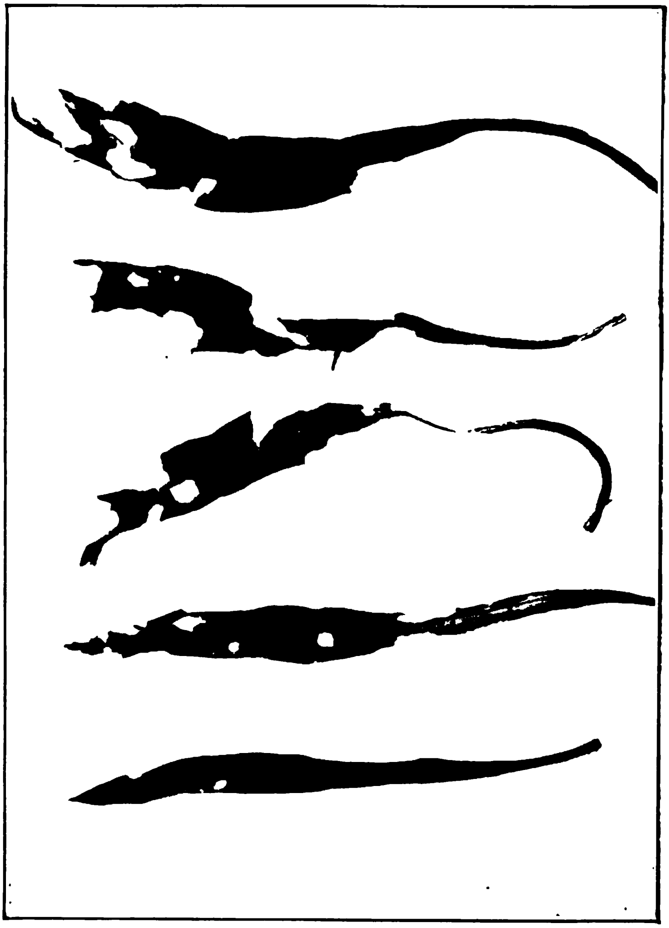
Potatoes injured by the Field Slug (*Agriolimax agrestis*). Photograph by T. Price.



EXPLANATION OF PLATE LVII.

PLATE LVII.

Wallflower Seedlings eaten by *Agriolimax* and *Helix rufescens.*
Photograph by T. Price.



EXPLANATION OF PLATE LVIII.

PLATE LVIII.

Shells of *Helix rufescens*. Photograph by T. Price.

EXPLANATION OF PLATE LIX.

PLATE LIX.

Cyclamen eaten by *Otiorrhynchus* grubs. Photograph by T. Price.

PLATE LIX.